MINISTRY OF AGRICULTURE, FISHERIES AND FOOD
DEPARTMENT OF AGRICULTURE AND FISHERIES FOR SCOTLAND
SCOTTISH HOME AND HEALTH DEPARTMENT

# Dairy Effluents

## Report of the Dairy Effluents Sub-Committee of the Milk and Milk Products Technical Advisory Committee

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This report on dairy effluents was prepared by a Sub-Committee set up for the purpose by the Milk and Milk Products Technical Advisory Committee.

The Milk and Milk Products Technical Advisory Committee was appointed in 1954 by the then Minister of Food, the Minister of Agriculture and Fisheries, and the Secretary of State for Scotland. Its task is to keep under review the technical problems arising at all stages of the handling, processing and distribution of milk and the manufacture of milk products; to inform Ministers of the problems requiring research and of desirable technical developments; and to advise on the best means of encouraging the adoption of such developments in the dairy industry. The present Chairman is Mr. J. Matthews, O.B.E.

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The Sub-Committee wishes to place on record its appreciation of the valuable assistance they have received from the Secretariat both in the sifting of the evidence they have received and in the preparation and final editing of the report.

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# Contents

Page

PREFACE . . . . . . . . . . . . vi

INTRODUCTION . . . . . . . . . . . viii

CHAPTER 1 Dairy Effluents and the Law . . . . . . 1

CHAPTER 2 Effluent Control . . . . . . . . 6

CHAPTER 3 Discharge to Sewers . . . . . . . . 14

CHAPTER 4 Discharge to Watercourses . . . . . . 24

CHAPTER 5 Methods of treatment before Discharge . . . . 32

CHAPTER 6 Summary and Conclusions . . . . . . . 53

APPENDIX I Public Health (Drainage of Trade Premises) Act 1937 57

APPENDIX II Notes on the Mogden Formula . . . . . 65

APPENDIX III References . . . . . . . . . 66

APPENDIX IV Glossary . . . . . . . . . 68

APPENDIX V Bibliography . . . . . . . . 72

# Preface

## (a) *Terms of Reference*

1. The sub-committee were asked to examine the powers of river authorities and local authorities to impose standards and charges for effluents, and the varying requirements for dairies, with particular reference to the imposition of heavy financial burdens on them. The sub-committee examined the problems arising from dairies negotiating direct with individual authorities; and the checking of effluent discharge with reference to the need for adequate sampling to ensure a good average and for uniform testing. An important element in these considerations was the variability of dairy discharges both by composition and by volume.

2. For dairies discharging effluents into sewers consideration was given to charges levied by local authorities, and the need for reasonable uniformity of assessment and the possibility of allowances being made for domestic and other effluents normally accepted as being covered by the rates.

3. The sub-committee also considered the pre-treatment of effluents before disposal, the reduction of effluent by prevention of waste, advice to dairy managements on the operation of effluent disposal plants and on simple improved methods of pre-treatment or on spray irrigation methods of disposal.

## (b) *How the Sub-Committee tackled its task*

4. The sub-committee prepared a questionnaire seeking information on the nature of the operations carried out; it was sent to 1,075 dairies and information was sought on the approximate volume and rate of discharge of effluent; on how the effluent was disposed of and whether any pre-treatment was required or carried out; on the restrictions or standards imposed by the local authority or river authority; on any charges levied and the basis on which they were levied and whether any allowance was made for domestic effluent.

5. As a result of the enquiries 384 returns were received from dairies covering almost 60 per cent of ex-farm milk supplies. Over 300 dairies reported discharging effluent into local authority sewers; most of the rest discharged into rivers but a few discharged into a ditch, into the sea or on to land. More than half of the dairies discharging into sewers are doing so without charge and the replies disclosed that charges levied by local authorities varied greatly. As a result of this, dairies performing similar functions, but situated in different local authority areas, found themselves incurring widely different costs even when the effluent volume was approximately the same. The reasons for this are discussed later. Moreover there was evidence that variation in charges existed even within the same local authority area. Of the dairies discharging effluent into rivers over 80 per cent were required to conform to standards imposed by the river authority. Most of these dairies had their own pre-treatment plant.

(c) *Consultations with River Authorities and Local Authorities*

6. A note listing points for discussion was prepared and sent to river authorities; apart from general matters these included questions as to standards and methods of treatment and sampling. Subsequently representatives of the river authorities met the sub-committee and had discussions with them. A similar procedure was used to consult local authorities, the main matters for discussion being conditions of discharge, sampling and charges.

# Introduction

(a) *Background Legislation*

7. The Public Health (Drainage of Trade Premises) Act 1937⁽¹⁾ established the right of occupiers or manufacturers to discharge into the public sewers of a local authority, subject to its consent, any trade effluent proceeding from their premises. The Act also provided that the local authority could impose conditions in relation to the consent, including charges for the receipt and disposal of the effluent.

8. The Act provided that the consent of the local authority would not be required if effluent of the same nature or composition had been discharged from the premises at sometime within the year ended 3rd March, 1937. As a result, no conditions (and hence no charges) could be made in relation to the discharge. The Public Health Act 1961⁽²⁾ removed this protection. All trade effluent discharges to sewers are now made with the consent of the local authority and subject to such conditions (including financial contributions) as it may require. The financial contribution required by the local authority may provide for the repayment of the whole or part of the costs incurred by the authority in receiving and treating the effluent. Legislation is dealt with in more detail in Chapter 1.

9. It first became an offence to discharge solid matter into a stream if it caused pollution or interrupted or interfered with the flow of the stream under the River Pollution Prevention Act of 1876⁽³⁾ which also prohibited the discharge of solid or liquid sewage into a stream. But the Act was difficult to enforce and the first general measure to control discharges into rivers was the Rivers (Prevention of Pollution) Act 1951⁽⁴⁾. The Salmon and Freshwater Fisheries Act of 1923⁽⁵⁾ made it an offence to put any solid or liquid matter into any waters to which the Act referred so as to cause them to be poisonous or injurious to fish.

10. In 1948 the River Boards Act set up boards for the whole of England and Wales except for the Thames, Lee and London areas for which special arrangements were provided. Further powers were given to the boards by the Rivers (Prevention of Pollution) Acts 1951 and 1961⁽⁶⁾. This legislation is also dealt with more fully in Chapter 1.

(b) *Effect on the Industry*

11. Dairies discharging effluent into sewers must comply with such reasonable requirements as may be placed upon them by the local authority. These commonly include a charge based on the volume and strength of effluent. This has the effect, on the one hand of providing the authority with revenue commensurate with the expenditure incurred in relation to the effluent and on the other of offering financial encouragement to the dairy to reduce wastage and to exert whatever control it can on the volume and strength of the discharge. As has been mentioned, of the dairies discharging into rivers over 80 per cent have requirements in the form of standards imposed upon them and nearly 90 per cent of these dairies pre-treat effluent before discharge. The industry is thus making great efforts to meet whatever requirements are placed upon it.

## CHAPTER 1

# Dairy Effluents and the Law

12. During the past hundred years an increasing interest has been shown in the quality of the nation's water supplies, and of the need to safeguard them. In particular there has been a growing understanding of the need to protect water against pollution.

*England and Wales*

13. It was public agitation which led in England and Wales to the passing of the Public Health Act 1875(7) and the Rivers Pollution Prevention Act 1876 at a time when the arrangements for the disposal of wastes and the prevention of pollution were so crude and ineffective that, with the rapid increase in population, rivers which were used as sources of drinking water were in danger of becoming nothing better than open sewers.

14. The Public Health Act 1875 required local authorities to treat and dispose of sewage and to do this in such a way that the purity and quality of the water in any stream into which the treated sewage was discharged was not affected adversely. The Rivers Pollution Prevention Act 1876 went further. Under it, it became an offence to discharge solid matter into a stream if it caused pollution or interrupted, or in any other way interfered with, the flow of the stream; the Act also prohibited the discharge of solid or liquid sewage into a stream. Manufacturers were allowed to discharge their effluents to a local authority's sewer subject to the effluent not damaging the sewer and to the latter being of sufficient capacity to take it.

15. The discharge of effluents to inland waterways was, prior to the Rivers (Prevention of Pollution) Act 1951, largely controlled by the provisions of the Acts of 1875 and 1876. In 1923, however, the Salmon and Freshwater Fisheries Act, which applies to tidal as well as non-tidal waters, was concerned with the purity of waters containing fish. Any person who puts any solid or liquid matter into any waters to which the Act refers, so as to cause the waters to be poisonous or injurious to fish, is guilty of an offence.

16. Prior to 1948, the prevention of pollution was the responsibility of some 1,700 individual bodies, local authorities, catchment boards and fishery boards. The River Boards Act 1948(8) set up river boards for the whole of England and Wales except for the Thames, Lee and London areas for which special administrative arrangements were provided. The establishment of these boards was an important stage on the way to the effective control of effluent discharges; they were given powers to require a person (subject to appeal to the then Minister of Health) to give information as to the discharge of any effluent by him. The boards were also authorised to obtain samples of any effluent being discharged to stream or watercourse.

17. The Rivers (Prevention of Pollution) Act 1951 imposed restrictions on new or altered outlets and new discharges and this and the 1961 Act (which brought under control pre-1951 discharges) will be of particular interest to rural dairies which discharge effluent to streams. Under the 1951 Act, a person could only "bring into use any new or altered outlet for the discharge of trade or sewerage effluent to a stream or begin to make any new discharge of trade or sewerage effluent to a stream" with the consent of the relevant river board. A river board was not permitted to withold consent without reasonable grounds for doing so, but the board could impose such conditions as it thought reasonable as to the nature, composition, temperature, volume or rate of the discharge. Thus, when a new dairy was built or when an existing one was so extended or modified that the volume or the strength of the effluent was increased, the consent of the river board had first to be obtained for the discharge of the new effluent. The Rivers (Prevention of Pollution) Regulations 1963(9) (made under Section 3 of the 1961 Act) empower a river authority to require an applicant to furnish a very full and detailed analysis of the effluent.

18. Although the 1951 Act referred only to new and altered effluents, the Rivers (Prevention of Pollution) Act 1961 extended control to cover pre-1951 discharges. The extended control operates so as to require a river board's consent to the discharge of any effluent no matter how long the discharge may have been continuing and the same conditions as for a new effluent may be imposed in regard to it. The 1961 Act repealed the powers previously vested in river boards to prescribe general standards determining whether or not an effluent was of a polluting nature.

19. The 32 river boards in England and Wales were replaced in 1963 by 26 river authorities which cover the whole of England and Wales except the London area (where the Acts are administered by the Thames Conservancy, the Lee Conservancy Catchment Board, the Port of London Authority and the G.L.C.). This change was brought about by the Water Resources Act 1963(10) which also made the new river authorities responsible for preventing the pollution of ground water as well as for conservation. Apart from this these authorities have inherited the powers formerly exercised by the 32 river boards set up under earlier legislation; their duties now also include the assessment, control and development of water resources. In fulfilling their responsibilities it is necessary for the river authorities to have regard to soakaways, etc., to ensure that they do not cause pollution of underground waters.

20. Where, under the Rivers (Prevention of Pollution) Acts 1951 and 1961, a manufacturer or processor seeks the consent of the river authority to the discharge of effluent, he must inform the authority of the nature and composition of the effluent, the maximum temperature of the effluent at the time it is discharged, the maximum quantity which it is proposed to discharge in any one day and the highest hourly rate at which it is proposed to discharge. The authority may attach such conditions as it considers reasonable in regard to any of these factors and may also require the discharger to provide facilities for the sampling of the effluent. It may also require the discharger to provide and maintain inspection chambers or manholes. Unless the written consent of the discharger is first obtained, a river authority cannot alter a condition attached to a discharge until a period of at least two years after it was imposed.

21. The Clean Rivers (Estuaries and Tidal Waters) Act 1960(11) extends the provisions of the Rivers (Prevention of Pollution) Act 1951 (as provided by section 6 of the 1951 Act) to 95 seaward areas around the coasts of England and Wales. These 95 areas constitute "controlled waters" and the consent of the appropriate river authority is required in respect of all post-1951 discharges into them.

22. The right of a manufacturer or processor to discharge domestic sewage into a public sewer was established by the Public Health Act 1936(12). The term "Domestic Sewage" includes waste from lavatories, wash bowls, baths and canteens. The Act also made it an offence to discharge into a sewer any material likely to damage it, any chemical likely to create a nuisance or to endanger health, or any petroleum spirit or carbide of calcium or any liquid at a higher temperature than 43·3°C (110°F).

23. The Public Health (Drainage of Trade Premises) Act 1937 prescribed the conditions under which trade effluents could be discharged into the sewers of the local authority. These conditions were modified by the Public Health Act 1961 and this latter Act is of special interest to the urban dairy. The conditions which now apply to all effluents are as follows:

(1) A trader or manufacturer must first obtain the consent of the local authority before discharging a new effluent or altering the nature or increasing the volume of an existing discharge. The trader is required to serve on the local authority a "trade effluent notice" setting out the nature and composition of the discharge and giving details as to the maximum daily volume and the highest rate of discharge. The consent of the local authority may be granted at its discretion subject to conditions.

(2) A local authority is authorised to enter into agreements with owners or occupiers of trade premises providing for the reception and treatment of trade effluent; the agreement may extend to cover financial arrangements for the repayment by the trader of the whole or part of the costs incurred by the local authority in receiving and treating the effluent.

(3) The Public Health (Drainage of Trade Premises) Act 1937 provided traders with a prescriptive right to continue to discharge an effluent which had been discharged before the date of the Act provided that neither its nature or composition, daily volume or rate of flow had been changed. The Public Health Act 1961 allows local authorities on serving notice to make a charge for the reception and treatment of such effluents provided no charge was mentioned in the previous Agreement, and to impose conditions.

(4) A local authority which has imposed conditions with regard to the discharge of an effluent is not permitted to vary those conditions more frequently than every two years.

*Scotland*

24. In Scotland, the law relating to the prevention of river pollution is contained in the Rivers (Prevention of Pollution) (Scotland) Acts 1951(13) and

1965(14). In essentials the law is the same as in England and Wales, except that the responsibilities of river purification authorities are virtually limited to the prevention of pollution, and do not include water supply or fishery protection. Nine river purification boards set up by the Secretary of State under powers provided by the Act of 1951 cover most of Scotland south and east of the Caledonian Canal; in the remainder of the country the functions of river purification authorities are carried out by twelve local authorities.

25. Sewerage and the drainage of trade premises to public sewers in Scotland will in future be governed by the Sewerage (Scotland) Act 1968(15). This Act, however, will not come into force until a commencement order is made by the Secretary of State, and no date has yet been fixed for this. County and town councils will be obliged, subject to a reasonable cost proviso, to provide sewerage for effectively draining their areas of domestic sewage, surface water and trade effluents and taking their public sewers to points at which the owners of premises will be able to connect their drains at reasonable cost to themselves. The 1968 Act, as it applies to discharges of trade effluent to local authority sewers, is very similar to the provision made for England and Wales in the Public Health (Drainage of Trade Premises) Act 1937 as modified by the Public Health Act 1961. The only substantial difference relates to the continuation of an "existing" discharge of trade effluent (i.e. one which was being made in the two years preceding the coming into operation of the Act). Such a discharge must be allowed to continue, but the local authority may attach to the making of such a discharge any condition (including financial charges) which would be imposed in relation to a new discharge and not only the restricted list of conditions imposed in England and Wales. On the other hand, the authority must be prepared to establish, on appeal, that any condition attached to an "existing" discharge is warranted by a change of circumstances following the coming into operation of the Act. Otherwise, the trader who wishes to discharge trade effluent to a sewer in Scotland will find himself subject to very much the same rules as apply in England and Wales.

26. Until the 1968 Act comes into operation, the situation in Scotland will continue to be governed by the existing provisions of the Burgh Police (Scotland) Acts 1892 to 1903(16), the Public Health (Scotland) Act 1897(17), and section 7 of the Rivers Pollution Prevention Act 1876. Some of the larger sewerage authorities, e.g. Aberdeen, Dundee, Edinburgh, Glasgow and Greenock, operate under powers provided by local Acts of Parliament, which will continue until they are superseded by the 1968 Act. Since these various provisions may continue in force for sometime, they are briefly described below, in so far as they are relevant.

27. The Burgh Police (Scotland) Act 1892 requires town councils to make such sewers as shall be necessary for effectual drainage of their burghs. Section 233 of the Act provides that owners or occupiers of distilleries, manufactories or other works shall be guilty of an offence if they allow any refuse, refuse water, steam or other substances to interrupt the flow of, or be injurious to, public sewers; or if their discharge is a hazard to health. These owners or occupiers are required to construct pools or reservoirs for such refuse and if, in the opinion of the council, it is impracticable to render such refuse inoffensive or

innoxious, they can be prevented from discharging it into the public sewers. The Public Health (Scotland) Act 1897 empowers county councils and town councils to construct such sewers as they think necessary for keeping their respective districts properly cleaned and drained. Owners or occupiers of premises are entitled, after due notice has been given to the local authority, to cause their drains to empty into the authority's sewer. This entitlement is subject to the two conditions that no damage is caused to the sewer by the discharge and that no nuisance is created. Section 116 of the Act also requires distilleries, manufactories and other works to construct pools or reservoirs for their refuse, or to use the best practical means for rendering it inoffensive or innoxious, before discharging it into any sewer. Section 7 of the Rivers Pollution Prevention Act 1876 requires a sewerage authority to give facilities to manufacturers to discharge liquids from their factories into the public sewers, provided that the sewers are of sufficient capacity and the effluent does not prejudicially affect them. There is no obligation on an authority to enlarge sewers or to provide new sewers for industrial effluents. Provisions relating to the discharge of trade effluents to sewers may also be found in local Acts applying to certain areas.

28. The provisions of the Water Resources Act 1963 do not apply to Scotland. Under the Water (Scotland) Act 1946(18), however, the Secretary of State has a duty to promote the conservation of water resources in Scotland and to appoint an Advisory Committee (the Scottish Water Advisory Committee) for the purpose.

*Common Law*

29. Throughout Great Britain riparian owners have rights in regard to water flowing past their lands but these rights are restricted in so far as they cannot be used to the detriment of other owners downstream.

## CHAPTER 2

# Effluent Control

### (I) Sources of effluent

30. The cost of disposing of a dairy effluent, whether in the factory's own treatment plant or via a local authority sewer, is largely dependent on two factors—the amount of milk solids it contains, and the volume. The first of these (the pollution load) determines the size of the actual purification units (e.g. filter beds) required. The second determines the size of pipes, tanks etc. It is convenient to consider these two factors separately.

31. The main sources of milk solids in the effluent may arise from:

(1) Spillage, leaks etc.

(2) Milk and milk products left in churns, piping and plant of all kinds before washing out.

(3) Processing losses, such as evaporator entrainment, butter washings and discharges from bottle washers.

(4) Wastage of surplus low-value material (whey and skimmed milk).

32. Table 1 summarises information collected from practical experience during the last 5–10 years. These data, expressed in terms of Biochemical Oxygen Demand (BOD), were mostly obtained by direct measurement and analysis of residues left in plant and of rinsings and other discharges entering drains, but do not include any significant contributions from sources 1 and 4 above. It is evident that, as might be expected, the major losses arise from cheese and butter-making and from processes involving cream, concentrated and dried milk and whey.

33. In addition to the actual milk solids content of dairy wastes, certain other components such as detergents may have an appreciable effect on methods and costs and costs of effluent disposal and these are discussed separately (paras. 49–52).

### (II) Identification of sources and estimation of losses

34. Before considering how to reduce effluent losses, these should be measured and accounted for, by a careful survey of all dairy operations to find out which contribute to the waste and how much. (Nominal, or "book-keeping", estimates of milk losses should not be used for this purpose). This requires careful sampling and measurement of each separate discharge, followed by analysis to determine its strength and hence the total amount of milk solids it contributes to the combined effluent. The sum of all these separate items must then be checked against a parallel examination of the whole dairy effluent, also carefully measured and sampled.

## TABLE 1

*Wastage arising from various dairying operations*

| OPERATION | (Pounds BOD per 1000 gal milk processed) | |
|---|---|---|
| | *Average* | *Range* |
| Milk reception, churn washing, cleaning up | 2·6 | 1·1–6·6 |
| Cooling raw milk, storage, washing tanks and pipelines | 1·9 | 0·7*–3·1 |
| Washing Tankers | 2·5 | 1·0–4·0 |
| Skimming, storing skimmed milk and cream | 1·4 | 0·9–2·4 |
| Skimming, storing skimmed milk and cream, plus cream pasteurising | 6·6 | 4·6–12 |
| Churning and washing butter | 4·6 | 2·5–8 |
| Evaporating skimmed milk to low total solids | 2·3 | 1·6*–3 |
| Evaporating skimmed milk to high total solids and spray drying | 7·4 | 1·4*–15 |
| Roller drying | 5·3 | 2·5*–13 |
| Pasteurising milk, and storage | 2·9 | 1*–5·4 |
| Bottling pasteurised milk | 1·1 | — |
| Bottle washing | 2·3 | 0·5–3·7 |
| Pasteurising milk, and storage, bottling pasteurised milk and bottle washing | 8·5 | 4·9–17 |
| Clotted cream | 12 | — |
| Cream pasteurising and packing | 7·9 | — |
| Cheesemaking (hard pressed) | 8·9 | 2·3–20 |
| Cottage Cheese (washed curd) | 150 | — |
| Condensing fresh whey (to low total solids) | 2·5* | — |
| Condensing stale whey (to high total solids) | | |
| Condensate | 7·5 | 3–15 |
| Plant washing | 6 | 2·3*–11 |
| Condensing sweetened separated condensed milk | 14 | 12–17 |
| Full cream evaporated milk with canning | 7·5 | 5–10 |
| Ice cream making and packing (estimated, not measured) | 16 | — |

NOTE (*a*) Figures marked * were obtained when the operations were done with special care to prevent wastage—usually following a special survey of the effluent losses.

(*b*) No range is shown where only one or two results are available.

(*c*) 1 gal whole milk is equivalent to approximately 1·1 lb BOD.

### (a) *Losses from individual dairy operations*

35. When the whole of the discharge under investigation can be bulked in one vessel, measurement and sampling is simple. Failing this, samples must usually be composites, as representative as possible of the whole discharge. Determination of the volume corresponding to such a composite may be quite difficult and must often depend on careful estimates rather than on actual measurement, the method depending on local circumstances and common sense. For example, the volume of water used for boiling out an evaporator can be calculated from its known capacity or dimensions; rinse water used for "following through" the milk in the heat exchanger can be drawn from a tank of known contents; water supplied from a hose can be estimated from the measured delivery rate; slow discharges and drips can be collected over a known period and measured. Flows in channels can be roughly estimated with the aid of small floats, or better by determining the dilution of a tracer such as a dye added upstream at a constant rate. In some cases a small calibrated V-notch weir can be temporarily fixed across a channel or the whole drain can be blocked off at a man-hole and the liquid collected and measured by pumping out at a known rate.

(b) *Measurement and sampling of total effluent*

36. If the whole of the day's effluent can be collected in a tank before discharge (e.g. prior to a chemical precipitation treatment), then the volume can easily be estimated with a calibrated dipstick; otherwise, measurement is best done with a flow-recorder, preferably with an integrator, on the drain receiving the mixed effluent. Such recorders usually measure the height of liquid above a calibrated weir or flume, using a float or pressure-sensing mechanism.

37. In all cases, the sum of the estimated volumes of washings etc. from all the factory operations should be checked against the estimated or measured total volume of effluent and against the (metered) factory water consumption after making allowances for evaporation losses and inclusion of evaporator condensate etc., thus ensuring that no unaccounted discharge of water is occuring.

38. The total effluent from a dairy commonly varies rapidly in composition and rate of discharge and "snap sampling", often used as a basis for trade effluent charges, can give misleading results.

39. When a collecting tank is available, sampling of the day's discharge after thorough mixing is very simple. Alternatively, if the effluent is all pumped at a known rate from a pump well into the disposal system, a drip sampler on the pump discharge with a time recorder on the pump motor can give an adequate estimate of volume as well as a fair representative composite sample. But choking of the drip outlet by solid matter in the effluent can be troublesome. A still simpler method is to draw off continuously from the drain into a collecting vessel at a slow uniform rate by means of a small pump, but unless the rate of flow of effluent is almost constant, this method can only give a rough approximation to a true composite sample. Sometimes only hand sampling, at frequent intervals, is possible, the sub-samples being bulked in amounts proportional to the estimated rates of flow.

40. In most cases the ideal method of sampling would be with an automatic proportional sampler. Many automatic samplers have been devised. These may cost up to £500 in addition to the flow recorder itself which is usually necessary. A recent survey of this subject has suggested the following requirements for a satisfactory automatic sampler. The first eight of these requirements seem the most important.

- (i) Robust construction, with minimum of working parts, particularly electrical equipment.
- (ii) Minimum of parts immersed in effluent or exposed to the moist atmosphere of a drain.
- (iii) Minimum maintenance; ease of servicing.
- (iv) Resistance to corrosion.
- (v) Freedom from choking.
- (vi) Ability to draw a sample truly representative of the liquid (including suspended solids) at the inlet to the sampler.
- (vii) If designed to collect a series of equal sub-samples into a single container, the volumetric accuracy of the sub-samples should be not less than ±5 per cent, and the frequency of sampling should vary directly as the rate of flow.

(viii) Continuous sampling is desirable, but failing this the frequency of sampling should be as great as possible.

(ix) If sub-samples are collected in separate containers, filling by means of a moving arm is preferable to use of a turntable.

(x) The first flush of liquid at each sampling should be rejected, so that only fresh liquid is included.

(xi) The sample container(s) should be easily removable for examination and cleaning in the laboratory.

(xii) If battery-driven, the sampler operation should not be adversely affected by any likely drop in battery voltage.

(xiii) The sampler should be enclosed, to exclude rain, frost, and dust.

(xiv) The sample containers should not be exposed to light, and ideally a refrigerator should be incorporated to prevent bacterial action before analysis.

41. None of the instruments of which descriptions have been published fulfil all these requirements and none is a truly continuous proportional sampler. Several which approach this ideal depend on a revolving scoop, a bucket elevator, or a special container, so shaped as to take a volume proportional to the flow rate as measured by the height of liquid above a weir or flume of known characteristics. Some flow recorders can be coupled to an automatic sampler that takes a given quantity of liquid each time successive pre-determined volume increments are marked up on the integrator. However, the units of volume so sampled are usually too large, and the time intervals too long, to give a true composite. Another type of automatic sampler takes equal sub-samples at fixed intervals into separate containers and a composite is made from these by mixing portions of each proportional to the increments of effluent volume shown on the recorder for the corresponding periods. Examination of such separate sub-samples may be useful in showing the approximate times when particularly potent discharges have occurred, but these times will be imprecise because of the limited number of containers that can be incorporated.

42. The above comments on samplers relate to their use in effluent survey work as indicated in the first part of this Section II. Where it is desired to do such sampling as part of a regular effluent monitoring operation, e.g. in connection with trade effluent charging by a local authority, then stringent requirements for accuracy and strict proportional sampling may be less important than the need for robustness and minimum maintenance. But there is little point in installing an automatic sampler unless there are facilities for doing the required regular analyses and unless appropriate action is taken in the event of abnormal losses being indicated.

### (c) *Analysis*

43. The strength of the effluent obtained during a survey on the lines indicated above is best assessed by the Chemical Oxygen Demand (COD) test*, which can be calibrated in terms of actual milk, whey, etc. concentrations. This method is also applicable to samples of mixed crude effluent, unless this contains much particulate material. With very concentrated wastes (say over 1 per cent total milk solids) it may be convenient to use a total solids estimation which can be directly converted into equivalent milk etc.

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*"Recommended Methods for Analysis of Trade Effluents"—Soc. Anal. Chem. 1958 p. 22

44. The BOD test* is less useful except for very weak wastes because of its inherent variability and the long time required, but it is commonly used for local authority trade effluent samples. The 4h permanganate test† often used in sewage works is unreliable with fresh dairy wastes. If desired, COD test results can be expressed as approximate equivalent BOD values by use of conversion factors obtained from tests on known dilutions of milk etc.

### (III) Reduction of losses

45. In general, the first objective should be to eliminate losses at source, next to recover previously wasted materials in a form suitable for inclusion with one of the manufactured products and thirdly to recover as much as possible of the rest in a form suitable for disposal otherwise than down the drain. The sources listed under section 1 above may be dealt with as follows:

(i) *Spillage etc.*

This type of loss can be prevented simply by "good housekeeping". Catching drips in churn lids is not satisfactory. Spilt milk powder is especially undesirable and should always be swept up before washing down.

(ii) *Residues in plant*

This is the most generally neglected type of loss. The aim should be to recover most of the product by careful draining and then a further quantity in the form of strong rinsings, using a limited quantity of water. If this system is well organised by passing the rinsings in logical sequences through the different items of plant, it is possible to end up with a relatively small volume of solution containing a large proportion of the milk that was not removed by draining. This is often worth evaporating or drying either with the bulk of the milk, or separately for animal feed. This system has been successfully operated at a number of dairies, with appreciable financial benefit because of reduced effluent costs and the value of the recovered product. It is especially important when dealing with plant for evaporating milk or whey.

(iii) *Processing losses*

Processing losses may be difficult to prevent. However, modern evaporators that are properly operated need produce only minimal entrainment into the condensate. Butter washings can be greatly reduced in strength by a quick pre-rinse of the butter after drawing off the buttermilk, on the lines suggested for plant; these rinsings can be processed with the buttermilk. Milk coming back to the dairy as residues in milk bottles is hardly within the dairy's control, but it may be possible to arrange to empty out the worst of such bottles into a churn before they go to the washer. Cheese-press whey is high in fat and comparable with milk in its polluting effect. It should be carefully collected and added to the bulk of the whey for separation and recovery.

(iv) *Wastage of surplus by-products*

Although deliberate wastage of skimmed milk and whey is nowadays quite unusual, it may still happen in exceptional circumstances where there are insufficient facilities for utilisation. Moreover, because of their low economic

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*"Recommended Methods for Analysis of Trade Effluents"—Soc. Anal. Chem. 1958 p. 35
†"Recommended Methods for Analysis of Trade Effluents"—Soc. Anal. Chem. 1958 p. 24

value, these products especially whey, are often handled carelessly, with excessive wastage and spillage. Their oxygen demand is extremly high, and the effect of this on a biological purification process can be quite serious. No such surplus should ever be discharged to an effluent treatment plant or town sewage works. Similar precautions to those recommended for other milk products should be taken to minimise losses of skimmed milk and whey.

46. The usual manufacturing outlets for whey are as concentrated or dried products. Other suggested methods of utilisation are as a medium for growing feed yeast, or as a source of various human food products. With all these methods, considerable expenditure on plant is necessary, which may well be uneconomic except at large factories and would be impracticable at small dairies or for irregular supplies. Much whey is used for pig feeding, but this outlet is not always available because the uncertainty of supplies makes farmers reluctant to start using it.

47. For non-productive disposal, discharge to sea or to a suitable soak-away is sometimes possible, though this must be done with due regard for any restrictions on such discharges imposed by river or other authorities. Spray irrigation of whey is also possible and is used to a considerable extent in other countries. It does however require an adequate area of grassland.

### (IV) Variation in losses with different types of plant

48. There is little evidence to show what difference, if any, there is in the wastage from different types of the same sort of plant. Far more depends on the manner in which the plant is operated. The entrainment loss from evaporators is one instance where plant design does have some effect. The modern calandria type appears to be the best in this respect. The older type of vacuum pan often caused serious losses. Another instance is the difference between modern foamless separators and the obsolete types which often caused excessive loss of foam, especially when separating whey. It is obviously desirable when installing new plant to consider the potential wastage therefrom and to select or modify the plant so as to minimise such losses.

### (V) Detergents, etc., in dairy effluents

49. In addition to the milk solids content, certain other constituents of dairy effluents may sometimes have a significant effect on methods and costs of disposal. The majority of detergents used for cleaning dairy plant are alkaline materials, usually caustic soda with or without additions such as phosphates, silicates, and calcium-sequestering compounds. Acids, chiefly dilute nitric, are sometimes used, usually in sequence with alkali. Chemical sterilising agents are usually hypochlorite or other active halogen compounds, quaternary ammonium compounds or iodophors. Small amounts of surface-active materials are also required to help in removing fat.

50. In general it may be said that the amounts of all these reagents used are relatively small and are so highly diluted by the effluent as to have no signifi-

cant effect on the BOD load or on the cost of treatment. Acid and alkali may partially neutralise each other, chlorine-type sterilants are rapidly inactivated by milk solids and the surface-active agents are usually selected to avoid any foaming problem.

51. Because of the cost of some of these materials there is an obvious incentive to use them economically. Wherever possible, it is good practice to conserve the partly-spent detergent for re-use, after making it up to strength again. A major use of alkaline detergents is in bottle washers and it is only this operation that is liable to cause difficulty in effluent disposal.

52. Bottling depot effluent may be highly alkaline. This can adversely affect the operation of small biological treatment plants and sometimes causes troublesome deposits of scale in sewers carrying hard local water. For both these reasons it is desirable to use and to discharge, only the minimum of alkali consistent with satisfactory performance of the bottle washer, otherwise an expensive neutralisation treatment with acid may be unavoidable. In all cases it is desirable to ensure that the discharge of strong spent caustic solutions (as distinct from the rinse water) should either be to a soak-away, or if put into the drain, should be spread over as long a period as possible.

## (VI) **Effluent-saving campaigns**

53. If they are to be permanently successful, conservation measures such as those described above do need adequate and continual attention from management and the full co-operation of the staff. Every effort should be made to make both parties fully "effluent conscious". It has been found that quite remarkably better results can be achieved if a little interdepartmental rivalry can be generated by arranging for regular sampling and testing and publishing of losses from different departments.

## (VII) **Water saving**

54. Reduction in strength is an essential part of an effluent-saving campaign, but a reduction in volume is also very important. Most dairies use unnecessarily large quantities of water. As a consequence of recent legislation, such extravagance will become increasingly uneconomic when charges for abstracted water are imposed by river authorities, towns' water becomes more costly, and trade effluent charges are levied by local authorities.

55. The obvious first step to be taken is to prevent actual waste, e.g. from running hoses by fitting trigger controls where possible and from over-flowing storage tanks by level controls. A hot-water ring main is preferable to separate steam-water mixers. Much dairy plant, especially churn and bottle washers, is commonly run with a much higher water consumption than is specified by the makers—and manufacturers could well see if designs could be improved to prevent this waste. Cooling water from all sources, including refrigerator compressors, etc., should always be reclaimed for other uses, or re-cooled wherever the cost of this compares at all favourably with the combined cost of buying

water and of disposing of it as effluent. Water cooled condensers for milk and whey evaporators and for refrigeration plant, can use very large quantities of water and even when this is re-cooled in a tower or otherwise, there is a significant loss of water by evaporation. Condensers cooled solely by *air* are now in use, so eliminating altogether the use of water for this purpose. Evaporator condensate, even when slightly contaminated, can be used in many ways instead of softened water—for boiler feed, plant cleaning and detergent solutions, etc.—but it should be monitored so that if excessive entrainment occurs the contaminated condensate may be diverted to the drain. If acid condensate is produced, as from whey, it can be neutralised by passing through a column of granular magnesium oxide.

56. It might be argued that a decrease in volume of the effluent will correspondingly increase the strength and so cancel the advantage. But the savings in water costs, pumping and trade effluent volume charge will still apply and the net effect will be a reduction in cost of disposal.

## CHAPTER 3

# Discharge to Sewers

57. Where suitable facilities exist it is best for waste waters from dairies, as from other trade premises, to be discharged to the public sewer, but since this method of disposal may cause local authorities special problems, the Public Health Acts require that their consent be obtained and their conditions satisfied (Chapter 1).

### (I) Special Problems of Dairy Effluents

58. The discharge of dairy effluents to public sewers may cause special problems for a variety of reasons, which are discussed in the following paragraphs.

*Volume*

59. The discharge to sewers of volumes of waste in excess of the design flow of the sewers will cause them to become surcharged in wet weather and lead to increased overflow of untreated sewage and trade waste to surface waters.

*Strength*

60. Some dairy effluents are much stronger than domestic sewage (Table 2) and their uncontrolled discharge to a sewer may impose a shock load on the sewage treatment plant, with which it is unable to deal. It may be necessary to control the rate of discharge of waste water and either add to, or alter, the treatment plant in order to treat the extra load. For example, if the plant employs

TABLE 2

*Comparison of the BOD of milk, milk by-products and typical dairy effluents, with that of domestic sewage*

| | Typical BOD (mg/l)* (or ppm)* |
|---|---|
| Milk | 110,000 |
| Skimmed milk | 72,000 |
| Separated Buttermilk | 72,000 |
| Separated Whey | 44,000 |
| Waste waters from: | |
| Milk reception depot | 300 |
| Milk bottling plant | 500 |
| Butter making | 500 |
| Cheese making | 2,000 |
| Drying and condensing milk | 1,500 |
| Milk products factory | 1,500 |
| Domestic sewage | 300 |

*(milligrams per litre or parts per million)

biological filters it may be necessary to change to alternating double filtration or to filtration with recirculation of effluent (Chapter 5). If the plant uses the activated-sludge process additional aeration may be needed at the inlet to the aeration tanks because of the high initial oxygen demand of the dairy waste. Also, problems may occur on account of 'bulking' of the activated sludge. Some wastes, particularly from cheese factories, if discharged to the sewer encourage the development of anaerobic conditions in the primary settlement tanks at the sewage works; offensive odours result and removal of sludge buoyed to the surface by gas bubbles is laborious and unpleasant.

### *Rate of discharge*

61. At some dairies the rate of discharge of waste waters varies within wide limits and is usually greater when the plant is washed. From some plants the discharge may be for only a short time each day. It is generally uneconomic to provide sewers and treatment facilities to deal with the maximum rate of discharge from such premises.

### *Temperature*

62. High temperatures resulting from the discharge of hot liquids to sewers encourage the development of septic conditions, especially in rising sewer mains. This may lead to odour nuisance and to the formation of hydrogen sulphide, which becomes oxidised to sulphuric acid on moist surfaces exposed to air and may then attack sewer pipes or their jointing and lead to their failure. Hot liquids, by causing excessive expansion, may damage rigidly-jointed sewer pipes; they may also cause short circuiting of liquid in settlement tanks on account of density currents and will generally increase the effects of other discharges.

63. In order to safeguard workers who may have to enter sewers or manholes the discharge to sewers of liquids having a temperature greater than 43°C (110°F) is usually specifically prohibited.

### *pH value*

64. Strongly alkaline waste waters such as, for example, those produced by bottle-washing plants, may damage sewers and by reacting with bicarbonate in sewage may lead to encrustation of sewers with carbonate scale. A sustained high pH value in sewage, greater than about 9, is likely to reduce the efficiency of the biological oxidation at a sewage treatment plant.

### *Seasonal variation in load*

65. The polluting load from a dairy is often much greater during the flush season than at other times of the year yet it is during this season that the flow in rivers is small and the effects of pollution are most serious. It may be uneconomic to provide a sewage works to treat this seasonal peak load and alternative means of dealing with it may be desirable. Disposal of a proportion of the effluent on grassland is one possibility.

### *Fat and curd*

66. Discharge of curd and fat is wasteful and should be avoided as far as possible; nevertheless some losses do occur. Since fatty wastes may coat sewers and lead to blockage, screens and grease traps must normally be provided.

## (II) Pre-treatment

67. Because of the problems which can arise when dairy effluents are discharged to sewers it is sometimes necessary to pre-treat the waste waters before discharge. In a few cases it may be desirable to provide partial biological treatment of the waste waters in order to reduce the BOD load reaching the local authority's works and thus reduce the charges for reception of the waste.

Pre-treatment may involve:

(a) Screening
(b) Separation of fat and scum
(c) Adjustment of pH value
(d) Balancing of flow
(e) Settlement.

68. In the majority of cases it is sufficient to provide screening and separation of fat and scum. Balancing of flow is necessary when the BOD load in the dairy effluent is large in relation to that of domestic sewage and the rate of discharge varies within wide limits during a 24 hour period; in other circumstances the effluent is best discharged in as fresh a condition as possible. At bottling plants relatively large amounts of alkaline detergents are used for bottle washing and the pH value of the discharge is high. It may become necessary therefore to provide equipment to reduce the pH value of the alkaline washings before they are discharged.

69. The equipment necessary for pre-treatment of waste waters is dealt with in Chapter 5.

## (III) Conditions

70. The Public Health (Drainage of Trade Premises) Act 1937 and the Public Health Act 1961 prescribed the conditions under which trade effluents may be discharged to the public sewer (see Chapter 1). These Acts apply in England and Wales with the exception of the London area. Similar provision will be made for Scotland by the Sewerage (Scotland) Act 1968, when it comes into operation.

71. Analysis of the replies to the questionnaire sent out by the Sub-Committee showed that, of 384 dairies in England and Wales, 311 discharged their effluent to local authority sewers. In 138 cases the local authority charged for reception of the effluent; in 173 cases no charge was made.

72. Where a charge was imposed, the dairies were required to conform with standards in respect of one or more of the following:

(a) pH value (48 cases)
(b) BOD (29 cases)
(c) Suspended solids (42 cases)
(d) Temperature (18 cases).

In 9 cases only did the local authority require the effluent to satisfy these four standards.

73. Where no charge was levied, only 10 dairies were required to comply with fixed standards.

74. There was little uniformity or consistency in the standards imposed by different authorities, probably because they were largely determined by local factors. Generally, however, pH values were required to be not less than 6 nor greater than 10, and temperatures not greater than 43°C (110°F). The permitted BODs ranged from 30 mg/l to 1,800 mg/l. Similarly, in other cases, the permitted contents of suspended solids ranged from 30 mg/l to 1,000 mg/l.

*Trade effluent notices*

75. In England and Wales, before first making a discharge a trader must obtain the consent of the local authority. The procedure is to serve on the local authority a "trade effluent notice" setting out the nature and composition of the proposed discharge and giving details of the maximum daily volume and the highest rate of discharge. The consent of the local authority may be granted at its discretion, subject to conditions, but must not be unreasonably witheld. In the case of discharges first begun since 1937 the local authority may impose conditions with respect to any or all of the following:

(a) the period or periods of the day during which the discharge may be made;
(b) the exclusion of all condensing water;
(c) the elimination or diminution of any specified constituents of the effluent before it enters the sewer where the local authority is satisfied that alone, or in combination with other material, it would injure or obstruct the sewers or make especially difficult or expensive the treatment and disposal of sewage, or where the outfall of the receiving sewer is into a harbour, or tidal water, whence there might be prejudicial effects, including obstruction to navigation;
(d) the temperature, acidity or alkalinity of the trade effluent;
(e) the payment of charges to the local authority for receipt and disposal of the effluent;
(f) the provision and maintenance of an inspection chamber and manhole as will enable a person at any time to take samples of what is passing into the sewer from the trade premises;
(g) the provision and maintenance of meters, etc.;
(h) the provision, maintenance and testing of apparatus for determining the nature and composition of any trade effluent discharged to the sewer;;
(i) the keeping of records of the volume, rate of discharge, nature and composition of the trade effluent; and
(j) the making of returns and giving of other information concerning the volume, rate of discharge, nature and composition of trade effluent so discharged.

76. In the case of discharges first begun before 1937 the local authority has the right to impose conditions with respect to sub-paragraphs (d), (e), (f), (g), (i) (volume and discharge only) and (j) above, but not with regard to (a), (b), (c), (h) and (i) (nature and composition).

77. When the Sewerage (Scotland) Act 1968 comes into force, the consent of the local authority must be obtained in Scotland before a discharge can be made, by serving on it a "trade effluent notice", setting out the nature, composition and temperature of the proposed discharge. In relation to "new" discharges (i.e. begun or substantially altered after the coming into operation of the Act) the conditions which may be imposed are as follows:

- (a) designation of the sewers into which the effluent may be discharged;
- (b) the nature or composition of the effluent;
- (c) the maximum daily quantity which may be discharged, either generally or into a particular sewer;
- (d) the maximum hourly rate at which the effluent may be discharged, either generally or into a particular sewer;
- (e) the period or periods of the day during which the discharge may be made;
- (f) the elimination or diminution of cooling water;
- (g) the prevention of injury to the health of persons engaged in carrying out the functions of the sewerage authority;
- (h) the elimination or diminution of any specified constituents of the effluent before it enters the sewer where it would injure or obstruct the sewers or make especially difficult or expensive the treatment and disposal of sewage;
- (i) the temperature, acidity or alkalinity of the trade effluent;
- (j) the payment of charges to the local authority;
- (k) the provision and maintenance of an inspection chamber and manhole as will enable a person at any time to take samples of what is passing into the sewer;
- (l) the provision and maintenance of meters, etc;
- (m) the provision, maintenance and testing of apparatus for determining the the nature and composition of any trade effluent discharged to sewer;
- (n) the keeping of records of the volume, rate of discharge, nature and composition of the trade effluent; and
- (o) the making of returns and giving of other information concerning the volume, rate of discharge, nature and composition of trade effluent so discharged.

78. Existing discharges (i.e. any which were being made in the two years before the 1968 Act comes into operation) will be allowed to continue, but the local authority may impose, in relation to them, any of the conditions that could be imposed in relation to a 'new discharge'. On an appeal to the Secretary of State against any such condition, however, the local authority must be prepared to establish that the imposition of the condition is justified by a change of circumstances after the coming into operation of the appropriate provisions of the 1968 Act.

*Right of Appeal*

79. A trader aggrieved by a direction, or a refusal or failure to give consent, or any condition imposed by a local authority in England and Wales has the right to appeal to the Minister of Housing and Local Government. In Scotland, under the Sewerage (Scotland) Act 1968 there will be a corresponding right of appeal to the Secretary of State.

*Model forms of consents*

80. Model forms of Consents and Directions are shown in Appendix 1 (L.A.A./C.B.I. Trade Effluent Joint Advisory Panel 1st July, 1964).

## (IV) Charges

81. Under the Public Health Acts 1937 and 1961, which, as mentioned, apply in England and Wales but not in Scotland, a local authority may, but is not obliged to, charge for the reception of trade effluent into its sewers, having regard to its nature and composition, the volume and rate of discharge and to any additional expense incurred or likely to be incurred in connection with its reception and disposal and to any revenue likely to be derived from the trade effluent. The charges may be such as to recover the full cost of dealing with the effluent. Furthermore waste waters from different dairies differ in strength: local authorities impose different conditions regarding pre-treatment of dairy effluents: and river authorities impose different conditions in respect of quality of effluent from local authorities sewage disposal works. For all these reasons wide variations occur in the charges imposed.

82. Corresponding statutory provisions will apply in Scotland under the Sewerage (Scotland) Act 1968. At present there are no specific provisions to that effect, though a sewerage authority which is providing a new sewer or expanding an existing sewer to take trade effluent may enter into an agreement with the trader whereby he contributes to the cost of doing so.

*Cost of Sewerage and Sewage Treatment to Local Authorities*

83. A local authority's financial liability in dealing with trade effluent is comprised of the following costs:

(a) the provision of capacity in the sewers for conveying the effluent to sewage works;
(b) the screening and removal of suspended solid impurities by settlement, and the biological treatment of the effluent; and
(c) the treatment and disposing of the resultant sludge.

84. The capital cost to the authority of providing capacity in the sewers and the period of retention in settlement tanks is roughly proportional to the maximum rate of discharge of trade effluent; the capital cost of biological treatment is roughly proportional to the amount of oxidizable organic impurity in the waste water after settlement, i.e. to the BOD load per unit time; and the capital cost of equipment for treatment and disposal of sludge is roughly proportional to the load of impurities in the unsettled waste per unit time. The BOD load (in lb) and what may be termed the impurity load, are calculated by multiplying the BOD, and the sum of the BOD and suspended solids content, respectively, expressed in units of mg/l, by the volume of effluent expressed in millions of gallons ($10^6$gal). The BOD enters into the calculation of impurity load since part of the dissolved organic matter is converted into secondary sludge. Thus biological treatment of waste waters initially free from suspended matter can result in the formation of sludge.

85. The capital cost of new sewers depends partly on the population served.

According to Townend, in 1959 it was £20 per person for a population of about 5,000, rising to £22 per person for a population of about 50,000, and about to £26 per person for much larger communities. Assuming new sewers are designed to carry 240 gal sewage/person day (6 DWF)* this represents about 4d. to 5d. per 1,000 gal sewage carried, when the flow is at its maximum (1959 value). The costs incurred by local authorities in biologically treating domestic sewage or sewage plus trade effluents, and the disposing of sludge, as reported by the Institution of Municipal Treasurers and Accountants, 1966 have been analysed by Bayley who reports(20) that the age and size of the works seem to be the most important factors. A multiple regression analysis of the data suggests that the following equation may be used as a rough guide for estimating the cost of treatment:

$$C = 4\cdot0 \left(\frac{Y}{1900}\right)^{49\cdot1} F^{-0\cdot3}$$

where C is the net service cost in 1965 (d./1,000 gal),† Y is the year the sewage sewage works were brought into use, and F is the dry weather flow ($10^6$ gal/d)‡. It will be seen that for a works built at the turn of the century and treating a dry weather flow of $10^6$ gal/d the cost might be about 4d./1,000 gal whereas for one brought into use in 1965 it would be about 21d./1,000 gal. Costs derived from the equation are in reasonable agreement with the 1959 values reported by Townend(19) if allowance is made for trade effluents at the larger works. The figures do not include the cost of providing sewers.

86. Analysis of detailed information from 27 of the larger works shows that the weighted mean cost of sludge treatment and disposal was 39 per cent of the

TABLE 3

*Cost of sewage treatment in new plants to give effluent to Royal Commission Standard*

(Based on Townend, J. Proc. Inst. Sew. Purif., 1962 (3), 209)

| Population | Annual expenditure per head in 1959 (shillings) | | | Assumed flow** ($10^6$ gal/d) | Cost per 1,000 gal (pence) | Cost (1965) derived from above Eqn. (pence) |
|---|---|---|---|---|---|---|
| | Operating cost | Loan charges | Total | | | |
| 1,000 | 20 | 21·9 | 41·9 | 0·03 | 46 | 51 |
| 10,000 | 12 | 14·5 | 26·5 | 0·3 | 29 | 26 |
| 50,000 | 8 | 12 | 20·0 | 2·5 | 13 | 14 |
| 100,000 | 6·5 | 11 | 17·5 | 5·0 | 11·5 | 11 |
| 200,000 | 5·5 | 10 | 15·5 | 10·0 | 10 | 9 |
| 500,000 | 4·0 | 9·0 | 13·0 | 25·0 | 8·5 | 7 |
| 1,000,000 | 3·0 | 7·9 | 10·9 | 50·0 | 7 | 6 |
| 1,500,000 | 2·5 | 7·5 | 10·0 | 75·0 | 6·5 | 5 |

**Allowing 30 gal/person day for populations of 10,000 and below.
Allowing 50 gal/person day for populations of above 10,000.

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*6 times dry weather flow.
†d./1000 gal=pence per thousand gallons.
‡$10^6$ gal/d =1 million gallons per day.

total works cost and for 21 works in the group was from 20 to 60 per cent of the total works cost.

87. Thus for a typical new works serving a population of about 25,000 and receiving a dry weather flow of $10^6$ gal/d the total cost of sewerage and sewage treatment and disposal might be about 2s. 3d. per 1,000 gal made up as follows:

(a) conveyance 5d.;
(b) treatment 14d.;
(c) sludge disposal 8d.

88. In assessing the cost of receiving a discharge of dairy effluent, account would normally be taken of the strength of the dairy effluent compared with that of domestic sewage. For a strong waste having a BOD about five times that of settled domestic sewage the figure might be at least 6s. 11d. per 1,000 gal on the basis of the above costs.

*Running costs*

89. The running costs associated with the reception of a trade effluent into a sewer, its conveyance to the local works, and its treatment by screening and settlement would probably be small, but would be related to the maximum rate of discharge of waste water or to the volume discharged per day. Running costs associated with biological filtration of the settled waste might also be small; those for treatment by the activated-sludge process would be greater than for biological filtration, but in each case the additional cost could be related to the BOD load. The running costs incurred in treating and disposing of sludge would normally be related to the impurity load in the trade effluent but, in particular cases, other factors such as the ease of filtration of the sludge or the effect of sludge on anaerobic digestion might be important.

*Charges imposed for effluent disposal from dairies*

90. Dairies generally fall into three classes; those which are only reception depots, those where the manufacture of dairy products is the principal function and those primarily concerned with processing and bottling milk for retail distribution. Siting of dairies, a material factor in the cost of effluent disposal, depends largely upon their nature; those manufacturing dairy products being normally situated in milk producing areas and those processing milk for retail sale being in urban areas.

91. In rural areas effluent discharge to sewers by a manufacturing dairy is likely to constitute a large proportion of the polluting load received by the local sewage works. On the other hand, the land necessary for either complete treatment or pre-treatment of wastes by the dairy is usually available at relatively modest cost. In urban areas the amount of the total polluting load contributed by a dairy's effluent may be quite small relatively, but problems involving considerable expense can arise from the uncontrolled discharge of strong effluents, or be brought about by the reaction of alkaline effluents with hard water.

92. The variability of charges levied by local authorities for the reception, treatment and disposal of dairy trade effluent is reflected in replies from dairies

in response to the questionnaire sent to them by the sub-committee. Of 311 dairies which reported that they were discharging effluent to sewers, 138 stated that the local authority imposed charges (or intended to) while 173 reported that the effluent was accepted without charge other than the normal rating levy. Most local authorities appear to base their charges on the volume and strength of the effluent and this would seem to be the most equitable method as it provides the local authority with revenue commensurate with the expenditure incurred in relation to any particular trade effluent and at the same time offers financial encouragement to the trader to reduce wastage and to exert other controls on the volume and strength of the discharge. Nearly half (67) of the dairies charged for discharging effluent to sewers reported that this was the method used.

93. Other methods of assessment reported were:

(a) the volume of water used by the dairy;
(b) the annual charge calculated on either the volume of effluent discharged related to the volume of sewage received and treated or as a proportion of the costs of operating the sewage works;
(c) a capital payment towards the cost of extending the sewage works or building new installations to handle the increased volume and polluting load of trade effluent in the area.

94. Charges based on volume and strength were expressed at a rate per 1,000 gal and ranged from 3s. 6d. to as low as 8d. The average was just below 1s. Water for cooling was generally assessed at a reduced rate, e.g. 10d. per 1,000 gal. The range in charges varied in accordance with the nature of the operations undertaken at individual dairies, as shown in table 4.

TABLE 4

*Charges for disposal of effluent to sewer (based on returns from 138 dairies)*

| *Activity* | Charge per 1,000 gal | | |
|---|---|---|---|
| | *Maximum* d. | *Minimum* d. | *Average* d. |
| Milk cooling . . . . . | 42·0 | 0·8 | 12·0 |
| Milk cooling, heat treatment and bottling . . . . . | 42·0 | 1·7 | 10·0 |
| Cheese making . . . . | 25·0 | 4·25 | 9·0 |
| Milk drying (two returns only) . | 24·0 | 4·0 | 14·0 |

*Annual Charges*

95. Where an annual charge was made the amounts varied from as little as £100 to as much as £1,200 per annum. In one extreme case it was 80 per cent of the cost of running the sewage works.

*Capital Payments*

96. The largest capital charges reported amounted to over £146,000 spread over 50 years with annual payments of over £4,300 for the first 15 years, over £3,400 for the second 15 and £1,500 for the remaining 20 years. No additional

charge is involved but assuming effluent discharge continues at the present maximum the capital charge represents an approximate rate as follows:

First 15 years 3s. 5d. per 1,000 gal
Second 15 years 2s. 8d. per 1,000 gal
Remaining 20 years 1s. 2d. per 1,000 gal

The position at the end of the 50 years is, of course, uncertain. If circumstances are unchanged the local authority may accept the dairy's effluent without charge, or impose only a charge for maintenance. On the other hand if further modifications to sewage works are required during, or at the end of, the 50 years because of changes in effluents being discharged, an adjustment to the agreement might be negotiated.

97. One dairy reported an initial capital charge of £26,300 plus an annual contribution towards operating costs. The annual payment (which is currently £1,300) is determined by the ratio of the dairy's effluent volume to the total volume dealt with at the works. Assuming repayment of the capital charge to extend over 20 years and that the dairy's maximum daily rate of discharge is maintained, this represents an approximate rate of 2s. 10d. per 1,000 gal.

### *Allowances for Domestic Effluent*

98. Some local authorities abate their charges for the reception and disposal of dairy effluent by making an allowance in respect of "domestic" effluent. The allowance is generally 5 gal/person day or 10 gal where canteen facilities are provided, but in some cases is 14 gal or 20 gal/person day. In other cases, the allowance given is not apparently directly related to the number of employees.

### *Allowances for Steam Losses*

99. Where the volume of dairy effluent is assessed by measuring the water intake, an allowance may be made for steam losses and also for loss of water by evaporation from water cooling plant. Allowances reported range from 0·5 per cent to 35 per cent of the in-flow, but mostly seem to be in the range 2 per cent to 4 per cent.

### *General*

100. In view of the wide variation in the charges levied by local authorities, it is clear that factors other than those already mentioned enter into the calculations. Such additional factors might well include outstanding mortgage charges on the sewage works. Where the works are new and mortgage or loan charges still operate, the amounts levied by the local authority for the acceptance and disposal of effluent would be higher than in other cases where the sewage works are free of such charges.

### *Conclusion*

101. The general conclusion reached from a study of charges levied by local authorities is that while some dairies pay considerable sums, representing something like the full cost of dealing with their effluent, others pay very much less, probably far less than it would cost them to purify their effluent on the site for discharge to a river.

## CHAPTER 4

# Discharge to Water Courses

102. As is the case with other trade effluents, dairy effluents may not be discharged to streams except with the consent of the appropriate River Authority or River Purification Board and in compliance with the conditions which the authority or board may impose.

103. New discharges of dairy effluent to "controlled" tidal waters (i.e. discharge first begun after 29th September 1960) are subject to control by river authorities but discharges first made before that date may also be subject to control if the authority has obtained a 'Tidal Waters Order'. The legislation has been described in Chapter 1.

104. The uncontrolled discharge of dairy effluent to a stream leads to effects similar to those brought about by sewage effluents or other sources of organic pollution, but because dairy effluents are potent sources of nutrients and, before treatment, may be much stronger than domestic sewage, their uncontrolled discharge may create special problems.

### (a) *Effects of effluents on streams*

105. A discharge of dairy effluent may affect the appearance of a stream by encouraging the growth of filamentous bacteria such as *Sphaerotilus natans*, the so called 'Sewage fungus', by making the water turbid and thus reducing the penetration of light essential for the photosynthetic processes of green plants, and by causing deposition of solids. Deposits of organic matter are objectionable because of their high oxygen demand and because of their smothering effect on plants, on animal life on which fish feed, and on spawning grounds.

106. For river life the most serious effect of pollution by organic matter, such as is present in dairy effluent, is on the dissolved-oxygen content of the water. In a stream there is a balance between the rate of utilisation of dissolved oxygen by living organisms and its replenishment from the air by photosynthetic processes. If the demand for oxygen increases, the concentration of dissolved oxygen in the water falls and if the demand is too great, asphyxiation of fish and other aquatic life occurs. In severe cases anaerobic decomposition sets in, leading to the production of offensive odours. The oxygen demand increases with temperature and is greatly increased in particular reaches if there is deposition of organic matter.

107. Organic pollution however also seriously affects the suitability of water for use as a public water supply, for livestock, for irrigation of farm crops and by industry.

(b) *Special problems of dairy effluents*

108. The special problems associated with the disposal of dairy effluents to streams are their possible high BOD and their rapid uptake of oxygen, their alkalinity and, in the case of effluents from cheese factories, their occasional high chloride content. The BOD load tends to be greatest during the peak season for milk production when the river flow is low and the demand for water high. Disposal of unsaleable milk residues and, during the peak season, disposal of surplus by-products such as whey is sometimes necessary. Such liquids should never be discharged to a stream since they cause excessive pollution.

(c) *Treatment required*

109. River authorities and river purification boards normally require that dairy effluent discharged to non-tidal streams should be treated to at least the Royal Commission 'standard' for sewage effluent, i.e. the contents of suspended solids and BOD should not exceed 30 mg/l and 20 mg/l (30:20 standard) respectively where the stream affords dilution with at least 8 volumes of clean river water. If the dilution afforded in dry weather is much less than this and particularly when the stream is used as a source of water for potable supply, river authorities may reasonably require an even higher standard of treatment. Besides imposing these limitations on BOD and suspended solids content, river authorities will usually stipulate that the pH value should not be less than 6 or greater than 9.

110. Lower standards of effluent quality are permitted for discharges to tidal waters. It should be noted however that the dilution available in many tidal estuaries is not so great as was at one time supposed. This is because the effect of the tide is often to cause substantially the same body of water to move to and fro in the estuary and therefore the flushing action is not very much greater than that brought about by the entry of fresh water. This is the case for example in the Thames estuary.

111. Discharges of dairy effluent to the 'open' sea are normally made by utilising the sewers and the sea outfall of a local authority. In such case the local authority generally requires that the effluent should not be substantially different in strength or character from domestic sewage. The dilution available in the sea is so great that normally the oxygen demand of a discharge is of little importance and provided that a suitably long outfall pipe is provided it is sufficient to screen the waste and remove any free fat which might cause troublesome 'slicks'.

112. Analysis of the replies to the questionnaire sent to dairy companies in England and Scotland showed that 57 out of 384 dairies discharged effluent to a river, 10 to a ditch or dyke and 2 direct to the sea. All but 10 of the dairies which discharged effluent to a river had their own effluent treatment plant. 6 of the dairies discharging to a ditch or dyke and 1 dairy discharging to open land also had their own treatment plant.

113. Of the 54 dairies with treatment plant 12 were able to discharge effluent without being required to conform to standards, but in most cases the question of standards was being considered by the river authority. Of the remaining

42 dairies, 36 were required to comply with the Royal Commission 30:20 standard for sewage effluents, usually with the additional requirement that the pH value of the effluent should be within the range 6–9. In the case of the remaining 6 dairies some modification of the Royal Commission standard was imposed.

114. The treatment processes used by the dairies generally consisted of settlement followed by biological filtration but there were many variations of this process (Table 5). One dairy had an activated-sludge plant.

TABLE 5

*Treatment processes employed by dairies*

| Ref. | Treatment process used | Number of dairies |
|---|---|---|
| (a) | Treatment with chemical coagulant (aluminoferric), settlement, and ADF. | 3 |
| (b) | Aeration in collecting tank, settlement and single or double filtration. | 6 |
| (c) | Settlement followed by alternating double filtration (ADF). | 17 |
| (d) | Settlement, dilution, and double filtration. | 3 |
| (e) | Settlement, dilution only. | 9 |
| (f) | Settlement, biological filtration, and disposal of effluent on land. | 10 |
| (g) | Filtration through sand or gravel followed by disposal of effluent on land. | 3 |
| (h) | Treatment in septic tanks followed by biological filtration. | 1 |
| (i) | As (h) but with final settlement. | 1 |
| (j) | Activated sludge. | 1 |

115. The various processes which can be used for the treatment of dairy effluents before discharge to non-tidal streams are described in Chapter 5. The process which has usually been recommended is settlement followed by alternating double biological filtration, but variants of this process can be used in certain cases, for example when the effluent is produced during a short period each day. The activated-sludge process and variants of it such as extended aeration, treatment in oxidation ditches, and contact stabilisation can also be used but are more liable to be upset by shock discharges of strong dairy wastes. Effluents which have been biologically purified to the 30:20 standard by such processes can be further improved by surface irrigation on grass plots at loadings of 0·06–0·23 mil gal/acre d(21) (674–2580 $m^3$/hectare d).

116. Dairies which are fortunate enough to be able to discharge their effluent to tidal waters are generally not required by river authorities to treat their effluent to the standard required for discharge to non-tidal streams and may therefore be able to use high-rate biological filtration with recirculation of treated effluent, or alternatively, the high-rate contact stabilisation process.

117. Some dairies dispose of excess effluent during the peak season by spreading it on grassland. When this method of disposal is employed and the effluent has not been biologically treated to the 30:20 standard it is usually essential to prevent direct run-off to a stream. The rate at which the effluent can safely be applied to the grassland is very much less than when irrigation is used for 'polishing' biologically treated effluents. On well drained land it is usually satisfactory to apply the effluent at fortnightly intervals, in a quantity equivalent

to not more than 1 in rainfall per fortnight, that is 22,600 gal/acre or a mean rate of 1,600 gal/acre day. In wet weather the possible rate of application without run-off occurring would be very much less.

(d) *River Authority standards*

118. The recommendation of the Royal Commission in respect of dairy effluent discharged to a stream was that its biochemical oxygen demand and content of suspended solids should not exceed 40 mg/l(22). This recommendation was made before there was practical experience of treating dairy effluent but it was considered that the standard should be attainable using the treatment processes available at the time.

119. River authorities do not accept that this recommendation should still apply to dairy effluents since it is now known that they can easily be treated to the standard required for domestic sewage and there is, in general, no reason to require different standards for dairy and sewage effluents. Also the Royal Commission assumed that the effluent would normally receive dilution with at least 8 volumes of clean river water but today this is rarely the case. A high proportion of the water in some English rivers consists of sewage effluent; in the case of the river Trent for example, as much as 40 per cent of the dry weather flow consists of sewage effluent.

120. Although the Rivers (Prevention of Pollution) Act 1951 empowered river boards to fix bye-law standards for new discharges to streams this provision was not used and has been repealed by the 1961 Act. River authorities are now required to consider each case on its merits and fix any standards having regard to local circumstances and the uses to which the stream water is put. Although river authorities consider the merits of each case it would appear from discussion with their technical officers that in general they consider that the minimum standard of purification required should be that reasonably attainable by biological treatment processes. As their working standard they use that suggested by the Royal Commission for domestic sewage effluent, but where local circumstances necessitate it they ask for a higher standard.

121. The standards imposed by river authorities for effluents discharged to non-tidal streams are generally as set out in table 6.

TABLE 6

*Standards imposed by various river authorities*

| | Typical limits | Range of values reported |
|---|---|---|
| Temperature (°C) | | 20–27 |
| pH value . . . | 6–9 | 5–10 |
| BOD (mg/l) . . | 20 | 15–25 |
| Suspended solids (mg/l) | 30 | 25–50 |

122. A limitation on the 'chemical oxygen demand' or 'dichromate value' of an effluent is not normally imposed.

123. A limit on the ammonia content of an effluent is imposed when water supply interests are involved or when conditions in the stream are such that the ammonia might be toxic to fish. Ammonia is objectionable in water to be treated for potable supply because it reacts with chlorine to form chloramines which are less effective than free chlorine as a sterilizing agent. Also, in order to destroy the ammonia, a concentration of chlorine nearly ten times the original concentration of ammonia must be added—this itself is undesirable. The toxicity of ammonia to fish increases with the pH value of the water, ammonium ions being relatively non-toxic. Discharges of ammonia are therefore likely to cause most difficulty in clean chalk streams, or in waters only slightly buffered with respect to pH value which become alkaline as carbon dioxide is utilised by algae and other plants in photosynthesis.

124. The technical problems of river authorities and sewage disposal authorities in laying down and complying with limits of quality for effluents more restrictive than those of the Royal Commission is the subject of a publication by the Ministry of Housing and Local Government(23). This publication explains the factors which river authorities should take into account in fixing standards for sewage effluents and should be helpful to the dairies having to comply with limits more restrictive than those recommended by the Royal Commission. It is unlikely that the future will see any major change in the requirements of river authorities in respect of effluents from dairies. Such trend as there is, is likely to be towards production of effluents of higher quality in respect of BOD. and suspended solids. The tertiary methods of treatment outlined in the above publication and in Notes on Water Pollution No. 22(21) will be of interest to dairies faced with this problem.

125. In testing effluents, river authorities generally rely on snap samples rather than on composite ones prepared by mixing together a series of individual samples in proportion to flow. Thus, effectively, a river authority requires that the effluent from a dairy should at all times conform with the standards of quality it has imposed and that the treatment plant should be capable of treating the maximum flow and strength of waste waters.

### (e) *Cost of dairy treatment of effluent*

126. Of the 54 dairies who treat their own effluent 27 have supplied information regarding the actual cost of the plant and the average annual expense of maintaining and running it.

127. Some of these plants were built many years ago and the figures given for the actual cost of the plant are not realistic in present day terms. In other cases records were simply not available.

128. It was therefore considered that running costs would be a more reliable guide and a better basis for comparison with the cost to dairies of discharging effluent to local authority plants.

129. The following table 7 sets out the average daily discharge of effluent and running costs for similar types of treatment plant.

## TABLE 7

*Summary of running costs according to type of treatment employed*
(*see Table* 5)

| *Dairy No.* | *Average total effluent discharge per day* gal | *Capital cost of plant* | *Date of construction subsequent additions and costs* | *Running costs per year* £ | *Average running costs per* 1,000 *gal* pence |
|---|---|---|---|---|---|
| (a) *Treatment with chemical coagulant (aluminoferric) settlement and ADF* | | | | | |
| 1. | 7,000 | — | — | 925 | 87 |
| (b) *Aeration in collecting tank, settlement and single or double filtration* | | | | | |
| 1. | 13,000 | £5,000 | 1937 | 613 | 31 |
| 2. | 72,000 | £19,000<br>original<br>£3,500 | 1936 | 2,340 | 21 |
| 3. | 120,000 | £90,000 | 1961<br>1964<br>1965, £3,000 | 2,770 | 15 |
| (c) *Settlement followed by alternating double filtration (ADF)* | | | | | |
| 1. | 60,000 | £40,000 | 1957<br>no additions | 3,850 | 41 |
| 2. | 40,000 | Est.<br>£30,000 | 1927<br>1950, 1953,<br>1960 | 3,180 | 52 |
| 3. | 26,000 | £6,500 | 1952<br>1967–£4,000 | 600 | 15 |
| 4. | 24,000 | Quotation<br>£5,000–<br>£7,000 | Prior to<br>1953 | 500–550 | 15 |
| 5. | 75,000 | — | — | 2,315 | 20 |
| 6. | 115,000 | £70,344 | 1958/59 | 2,830 | 16 |
| 7. | 32,500 | — | — | 2,145 | 40 |
| 8. | 265,000 | — | — | 3,580 | 8·5 |
| 9. | 197,500 | — | — | 4,010 | 13 |
| (d) *Settlement, dilution and double filtration* | | | | | |
| NIL | | | | | |

Table 7 *continued*

| *Dairy No.* | *Average total effluent discharge per day* gal | *Capital cost of plant* | *Date of construction subsequent additions and costs* | *Running costs per year* £ | *Average running costs per* 1,000 *gal* pence |
|---|---|---|---|---|---|
| (e) *Settlement, dilution only* | | | | | |
| 1. | 70,000 | No information | 1920's | 450 | 8 |
| 2. | 1,600 | N/K | — | 20–25 | 9 |
| 3. | 125,000 | — | — | 332 | 1·5 |
| 4. | 50,000 | — | — | 75 | 1 |
| 5. | 15,000 | — | — | 25 | 1 |
| (f) *Settlement, biological filtration and disposal of effluent on land* | | | | | |
| 1. | 11,000 | £5,000 | 1957 £5,000<br>1963 £2,300<br>1965–66 £1,300 | 350 | 20·5 |
| 2. | 150,000 | £2,351 | 1936 £2,351<br>1951 £1,721<br>1954 £299<br>1957 £1,921<br>1958 £31<br>1960 £22,537<br>1967 £115 | 1,705 | 7 |
| 3. | 20,000 | £2,841 | 1936<br>addition 1962<br>1965 | 843 | 27·5 |
| 4. | 18,000 | N/A | Pre 1948<br>1960 £500 | 250 | 9 |
| 5. | 85,000 | — | — | 4,340 | 33 |
| (g) *Filtration through sand or gravel followed by disposal of effluent on land* | | | | | |
| 1. | 8,000 | — | 1956 | 52 | 4 |
| 2. | 9,000 | — | — | 335 | 24·5 |
| (h) *Treatment in septic tanks followed by biological filtration* | | | | | |
| 1. | 30,000 | £2,276 | 1937<br>1955 £1,956<br>1967 £602 | 450 | 9·5 |

Table 7 *continued*

| *Dairy No.* | *Average total effluent discharge per day* gal | *Capital cost of plant* | *Date of construction subsequent additions and costs* | *Running costs per year* £ | *Average running costs per 1,000 gal* pence |
|---|---|---|---|---|---|
| (i) *Treatment in septic tanks followed by biological filtration but with final settlement* | | | | | |
| NIL | | | | | |
| (j) *Activated Sludge Plant* | | | | | |
| 1. | 38,000 | £14,406 | 1960 | 3,100 | 53·5 |

130. As indicated previously, account has not been taken of capital costs in arriving at a figure for cost per 1,000 gal of effluent treated. It can be seen that costs per 1,000 gal vary widely even among dairies having the same type of plant. As might be expected the simpler effluent plants (see Table 7e) are cheaper to run, particularly where there is no standard to be met and disposal of the final effluent is less of a problem, e.g. disposal to land etc.

131. It would seem therefore from Table 8, that where a full treatment plant is installed the average running cost of treating 1,000 gal of effluent is about twice that of the discharge to local sewage works (see Table 4).

132. There is however one exception and that is the case of dairies concerned only with milk cooling, heat treatment and bottling. Here, on the basis of the information supplied, it appears to be cheaper for the dairy to treat the effluent itself rather than to discharge to the sewer. It should be appreciated however that the methods of treatment in these cases are relatively simple, involving little maintenance or running costs and no expensive plant.

TABLE 8

*Costs to dairy of treatment of effluent (based on returns of* 27 *dairies*

| *Activity* | Costs per 1,000 gal | | |
|---|---|---|---|
| | *Maximum* d. | *Minimum* d. | *Average* d. |
| Milk cooling (two returns only) . | 87 | 31 | 59 |
| Milk cooling, heat treatment and bottling . . . . . | 15 | 1·5 | 7·5 |
| Cheese Making . . . | 27·5 | 8 | 15·3 |
| Milk Drying . . . . | 53·5 | 1 | 25·3 |

It will be seen that there is a wide variation in the costs to dairies.

## CHAPTER 5

# Method of Effluent Treatment before Discharge

133. After simple pre-treatment, waste waters from dairies must normally be treated by a biological process in order to produce an effluent of the quality required for discharge to surface waters. This is because about one half of the impurity present in the waste waters consists of sugars which cannot be removed cheaply by a simple physical or chemical process. In a biological process however they are readily oxidised to carbon dioxide, or converted to matter in suspension which can be removed by settlement.

134. Some of the problems which arise when dairy effluents are discharged to a sewer for treatment in admixture with domestic sewage have been outlined in Chapter 3. These problems may be greater when the waste waters are to be treated at the dairy because the beneficial dilution with domestic sewage is not available. The same preliminary treatment may therefore be required.

135. The necessary preliminary treatment may include:

(a) Screening
(b) Separation of fat
(c) Control of pH value
(d) Balancing of flow and composition
(e) Settlement.

Settlement and skimming to remove fat may be carried out in a single tank. Balancing of flow and settlement may also be combined and when this is done the composition also tends to be evened out.

136. Treatment with chemical coagulants or by aerobic fermentation may precede settlement but will be described later as preliminaries to single filtration.

*Screening*

137. Bar screens should be provided to remove adventitious material which might choke or damage pumps.

138. At cheese factories relatively fine screens are necessary to remove curd. These may be of basket form and, if suitably situated near to the source of waste and emptied regularly, the solids collected may be useable for animal feeding.

*Control of pH value*

139. Biological treatment plants operate most efficiently when the pH value of the feed liquid is in the range 7–8, but feed liquids with a pH value of up to about 10 can be tolerated, since acids produced by fermentation during settlement and carbon dioxide formed by oxidation of organic matter reduce the pH value in the biological stage of treatment.

140. If the discharge of alkaline detergents raises the pH value significantly above 10 some control of pH value is likely to be necessary. It may be sufficient to store the alkaline liquids in a tank, discharging them from it at a constant rate over a 24 hour period. With this system provision must be made to avoid gelatinous solids choking the outlet. At bottling plants, where relatively large amounts of alkali are used for cleansing, addition of acid may be required to reduce the pH value to an acceptable level. There is pH control equipment commercially available.

*Balancing tank*

141. To ensure an even flow an equalising tank is required. This is best designed so that it empties completely at least once per day, otherwise sludge accumulates and contents become septic. The outlet may be in the form of a floating arm with an orifice plate or, less satisfactorily, a weir, or if the flow is relatively large may be by means of a module—a float operated device which controls the level of liquid in an outlet compartment of the main tank, from which liquid is drawn at a constant rate through an orifice. The floating orifices or weirs must be protected against blockage by suspended solid matter, and when floating arms are used a separate sludge outlet is essential. An alternative method of controlling the flow is to pump liquid from a sump at the bottom of the tank at the required average rate for uniform flow over a 24 hour period.

*Settlement*

142. To achieve settlement in the waste waters it is best to provide a hopper-bottomed settlement tank (Fig. 1) which can be desludged without first running off the supernatant liquid.

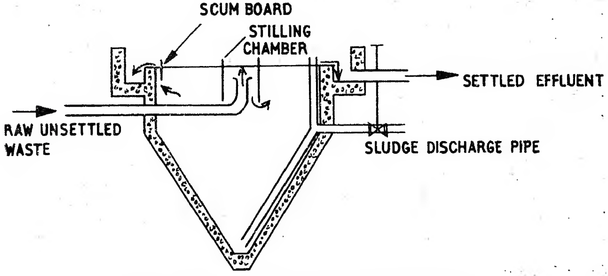

Fig. 1. Section of typical upward-flow settlement tank.

143. A 4 hour period of settlement is usually adequate. Prolonged settlement is not necessarily advantageous because septic conditions rapidly develop and difficulty may then be experienced from rising sludge. The reduction in the BOD of the waste brought about by settlement is usually small—of the order of 15–20 per cent.

144. After pre-treatment and settlement the waste waters still contain some emulsified fat and protein and dissolved organic matter and must usually be further purified by a biological process such as biological filtration or treatment with activated sludge.

*Biological Filtration*

145. In this process the waste waters are evenly distributed over the surface of a bed of suitably graded, inert, media such as hard clinker, blast furnace slag, broken rock, or even gravel (Fig. 2). As the liquid percolates through the bed, bacteria and other micro-organisms grow as a slimy film on the surface of the medium, feeding on the organic impurity absorbed from the waste. Some of this is oxidised to carbon dioxide, water, and other stable end products, and the remainder is converted to new cell growth. In time a balanced community of bacteria, fungi, protozoa, worms, fly larvae, and other organisms develops. The protozoa in the film feed on the bacteria, and the worms and fly larvae feed on the film. These organisms void solids and dislodge pieces of film which are carried away in the effluent and are removed, as humus sludge, by settlement. The amount of film in a filter depends amongst other things on the rate of application of organic matter. If the load is too great, or if too strong a liquid is applied, the film grows to such an extent as to seal the spaces between the medium. Liquid applied to the surface then forms in puddles, the performance of the filter deteriorates, and, because circulation of air through the filter is impeded, the film may decompose anaerobically and unpleasant smells may result.

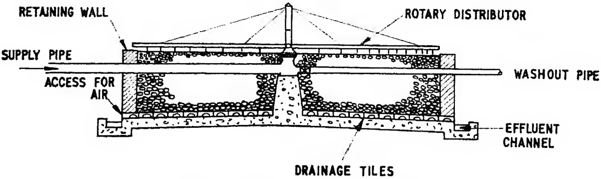

Fig. 2. Diagram of a biological filter.

146. Many factors affect the performance of a filter; for example, the size, roughness and uniformity of grading of the medium, the rate, periodicity and method of application of liquid, the depth, the degree of ventilation, and the operating temperature(24). Filters may be used singly, in pairs, in series, or in pairs in series with periodic reversal of the order.

*Single filtration*

147. Work by the Water Pollution Research Board has shown that biological filters of the conventional type treating dilutions of milk soon become choked at the surface by heavy accumulations of biological film and fat. This occurs with washings containing as little as 0·17 per cent milk(25)(26)(27).

148. It is therefore generally accepted that single filtration cannot successfully be used for treatment of milk washings unless the waste is first pre-treated

to remove fat and protein, for example by chemical coagulation(28) or by allowing the milk washings to ferment(29).

149. Where single filters are successfully employed without such pre-treatment of the waste there is usually a flow to the plant for only a short period each day and purified effluent is continuously recirculated to the filters as indicated in Fig. 3. Such plants are therefore effectively alternating double-filtration plants operated on a 24 hour scheme.

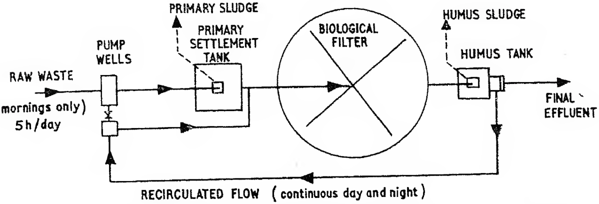

Fig. 3. Flow diagram of pseudo alternating double filtration system for a milk reception depot from which wastes are discharged for a short period every day.

150. When a waste is too strong for direct application to a filter over a long period, it is common for purified effluent to be recirculated to dilute the raw or settled waste. Such recirculation is usually designed to achieve suitable volumetric loading of the filter and to minimise surface growth. It does not enable the BOD loading of the filter to be increased above usual design standards unless the rate of recirculation is high enough to reduce the strength of the liquid applied to the filter to well below the normal design figure of 300 mg/l.

### *High-rate filtration with recirculation*

151. Milk washings can be treated on biological filters containing a coarse (4–6 in.) medium at high volumetric loadings when purified effluent is recirculated at a high rate to dilute the liquid applied(30) but such treatment does not produce an effluent suitable for discharge to fresh-water streams in Great Britain. However, high-rate filters could be used to reduce the strength of a waste before discharge to a public sewer or before discharge to tidal waters.

### *Double filtration*

152. Double filtration without alternation of the filters is not a suitable method for treatment of dairy wastes unless the primary filter is designed as a coarse roughing-filter operated with a high rate of recirculation. The reason for this is that, if the primary filter is of conventional design, in order for there to be any advantage the BOD loading needs to be at least twice that of a single-stage filter, and this would clearly lead to rapid ponding.

### *Alternating double filtration*

153. This process was developed by the Water Pollution Research Board to overcome the difficulties due to ponding of filters treating milk washings.

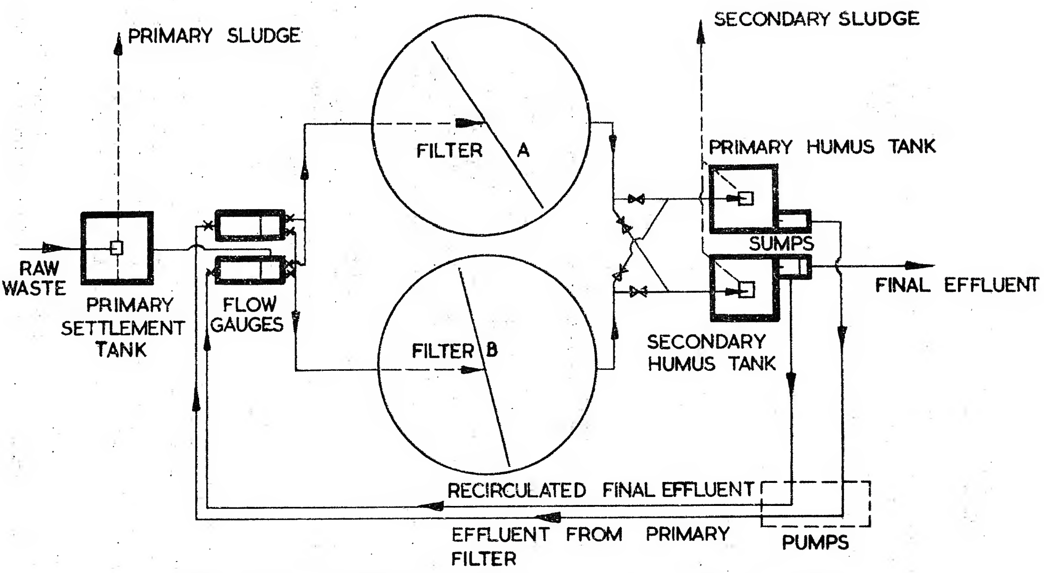

Fig. 4. Diagram of an alternating double filtration plant with provision for recirculation of final effluent.

Plants have been built at a number of dairies, and when operated under design conditions it is understood they give effluents of consistently good quality.

154. The waste waters after settlement are diluted with recirculated final effluent so that their BOD is of the order of 300 mg/l and are then passed through two filters in series with settlement after each filtration stage (Fig. 4). At intervals, usually weekly, the order of the filters, but not of the settlement tanks, is reversed.

155. The primary filter removes most of the impurity and produces an effluent which, after settlement, may have a BOD as low as 20 mg/l. When this primary effluent is applied to the secondary filter, any surface accumulation of film which has resulted from its previous use as the primary filter is dispersed and washed out in the effluent. In this way both filters are kept free from troublesome ponding. The quantity of polluting matter which can be removed per cubic yard of medium in the two filters together per day using this method of operation is greater than can be removed from, for example, settled domestic sewage by single filtration. The recommended design loading for an alternating double filtration plant is 0·48 lb BOD/$yd^3$ d (286 g/$m^3$ d)—equivalent to a hydraulic loading of 160 gal/$yd^3$ d (1952 l/$m^3$ d) when the waste has a BOD of 300 mg/l. Such a plant should be capable of consistently producing final effluent having a BOD of about 10 mg/l.

156. The performance of the Water Pollution Research Laboratory experimental filters and of some alternating double filtration plants subsequently constructed are given in Tables 9 and 10 respectively.

157. The capital cost of an alternating double filtration plant is high but the running costs are small compared with those of the activated-sludge process.

TABLE 9

*Average results of operation of an experimental alternating double-filtration plant*

| Liquid treated | Rate of application of settled and diluted crude liquid | | BOD (mg/l) | | | | Temperature of final effluent |
|---|---|---|---|---|---|---|---|
| | (gal/$yd^3$d) | (l/$m^3$d) | Crude liquid | Settled and diluted crude liquid | Settled effluent from primary filter | Settled effluent from secondary filter | (°C) |
| Milk-washings | 81 | 482 | 820 | 210 | 24 | 8 | 7·5 |
| | 124 | 737 | 1,280 | 230 | 14 | 8 | 13 |
| | 164 | 976 | 600 | 210 | 7 | 3 | 15 |
| | 160 | 952‡ | 210 | 110 | 11 | 8 | 10 |
| | 164* | 976 | 230 | 170 | 15 | 8 | 7 |
| | 240† | 1,430 | 600 | 300 | 14 | 10 | 17·5 |
| Whey-washings | 106 | 630 | 630 | 270 | 29 | 6 | 11 |
| | 132 | 785 | 560 | 210 | 13 | 6 | 11 |
| | 160 | 952 | 830 | 270 | 28 | 7 | 19 |

*Plant operated for only 16·5 h daily

†Period of alteration of filters needed to be reduced from 3 weeks to 10 days to prevent ponding.

‡About 1 filter bed volume per day.

TABLE 10

*Maximum and average conditions of operation of four alternating double filtration plants treating dairy wastes*

| Plant | A | B | C | D |
|---|---|---|---|---|
| Volume of waste per day | | | | |
| Maximum (gal) | 160,000 | 60,000 | 120,000 | 90,000 |
| ($m^3$) | 725 | 272 | 545 | 408 |
| Average (gal) | 130,000 | 20,000 | 60,000 | 40,000 |
| ($m^3$) | 590 | 91 | 272 | 181 |
| BOD (mg/l) | | | | |
| Maximum | 1,500 | 700 | 400 | 1,600 |
| Average | 600 | 300 | 250 | 700 |
| Recirculation ratio (Raw: recirculated) | 1:1 | 2:3 | 1:1 | 1:3 |
| BOD loadings of filters | | | | |
| Maximum ($lb/yd^3d$) | 0·86 | 0·48 | 0·338 | 0·52 |
| ($g/m^3d$) | 512 | 286 | 201 | 309 |
| Average ($lb/yd^3d$) | 0·36 | 0·069 | 0·106 | 0·102 |
| ($g/m^3d$) | 214 | 41 | 63 | 60 |
| BOD of effluent (mg/l) | | | | |
| Maximum | 30 | 10 | 6 | 15 |
| Average | 8 | 3 | 4 | 4 |

*Costs*

158. The cost of a biological filter of the conventional type (without the associated settlement tanks, pumps, etc.) depends to a significant extent on whether filtering medium is locally available. As a guide, it may be assumed that the cost, inclusive of distributors etc., would range from about £12 10s.* per cubic yard of medium for a filter of 20 ft. diameter (70 $yd^3$) to £8* per cubic yard for a filter of 100 ft. diameter (1740 $yd^3$). The total cost of a treatment plant related to the capacity of the biological filters would probably be at least twice this figure.

## Treatment with Activated Sludge

*Activated-sludge process*

159. In this process the waste waters are mixed and aerated with a flocculant suspension of micro-organisms termed activated sludge. This has previously been grown by aeration of the waste waters or of domestic sewage and consists of a variety of bacteria of the types commonly present in soil, in different stages of development, aggregated together with organic debris, protozoa, and occasionally fungi. The organisms feed on the organic impurity in the waste waters, and, as in a biological filter, oxidise some to stable end products such as carbon dioxide, water, and ammonia, and convert some to new bacterial cells. The process is carried out in one or more tanks to provide the necessary period of contact (Fig. 5). The mixed liquor then flows to a settlement tank where the activated-sludge is separated before being re-cycled to mix again with the incoming waste. In a properly working plant the overflow from the settlement

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*Data 1967

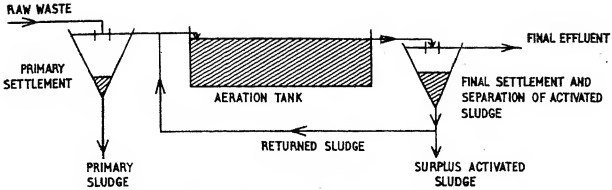

Fig. 5. Diagram of activated-sludge process.

tanks is clear and is suitable for discharge to a stream. There is a continual growth of activated-sludge during the treatment process and, when the required concentration in the mixed liquor has been reached, the surplus is removed continuously for disposal. The different types of activated-sludge plant differ principally in the method adopted for aeration of the mixed liquor, the design of tank, and the period of contact of waste with the activated-sludge. With filters the most common difficulty is ponding. With the activated-sludge process the sludge tends to become bulky. When this occurs sludge does not settle efficiently and may be lost in the final effluent. Also, the reduced concentration in the sludge recycled to the aeration tank leads to a progressive decrease in concentration of activated sludge in the mixed liquor, and may result in a further deterioration of performance.

160. The conventional activated-sludge process was studied by the Water Pollution Research Laboratory in the 1950s for treatment of milk washings and washings containing whey.(25) In their experiments the periods of aeration used ranged from 24 h to 36 h and the BOD loadings were mostly in the range 22–31 lb/1,000 $ft^3$ aeration tank capacity per day (350–500 $g/m^3$ d). Although it was found that the process was capable of producing effluents of good quality considerable care was needed to maintain the sludge in such a condition that it could easily be removed by settlement. The system was more liable to be upset by flushes of strong liquid than was the alternating double filtration process and the latter process was recommended.

161. More is now known about the activated-sludge process and it is probable that a plant could be designed to produce satisfactory effluents more cheaply than by alternating double filtration but it would probably be essential to balance the flow and strength of the factory waste.

162. The area of land required and capital cost of plant is less than for filters but running costs are high and skilled supervision is required.

*Oxidation ditch*

163. The oxidation ditch, or Pasveer ditch, is essentially a cheaply constructed form of activated-sludge plant in which the aeration tank takes the form of a ditch or channel. It is usually designed to provide a relatively long period of aeration of a waste; it is therefore fairly robust and with some types of waste is more reliable than the more heavily loaded conventional type of plant. It is

reported to have been successfully used for the treatment of dairy wastes.(30–33) Because of its simple construction the capital cost of the plant may be low—as little as one half of that for a plant of conventional design—but maintenance costs may be relatively high.

164. A typical ditch* consists of an elongated oval channel several metres wide and about 1½ metres deep (Fig. 6) provided with one or more electrically driven brush rotors(30) which aerate and circulate the contents of the ditch and keep the activated-sludge is suspension. Liquid drawn from the ditch is settled and the activated sludge recycled as in a conventional activated-sludge plant.

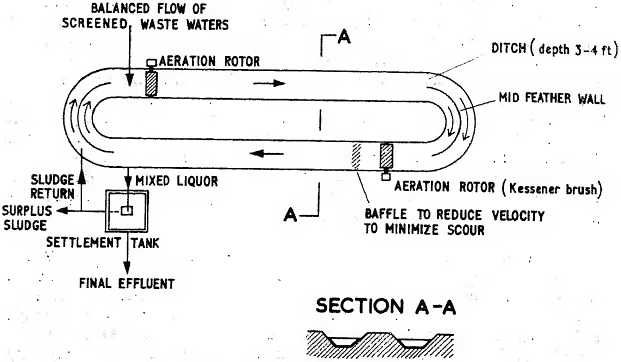

Fig. 6. Diagram of an oxidation ditch.

165. In its simplest form the ditch is dug with sloping banks and unless the soil is very permeable can be unlined except in the vicinity of the aeration rotors and the bends. In more recent installations the 'ditch' takes the form of an elongated oval concrete tank with a central longitudinal baffle around which the liquid circulates. Mid-feather walls at the ends help the flow of liquid round the bends.

166. The plant is usually designed for a BOD loading of about 12–15 lb BOD/1,000 ft$^3$ aeration channel capacity per day (175–245 g/m$^3$d) which may be compared with a loading of 20–30 lb BOD/1,000 ft$^3$ (327–490 g/m$^3$) in a conventional activated-sludge plant.

167. An oxidation ditch installed at a Co-operative Creamery at Baignes, France, is stated to reduce the BOD of waste waters from 3,000 mg/l to 14 mg/l.

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*This process is subject to a patent

168. Reports from Holland(32) indicate that special care must be taken in starting up a plant if bulking is to be avoided. A large inoculum of a dense rapidly settling activated sludge virtually free from *Sphaerotilus* is necessary, and at this stage, great care must be taken to avoid overloading of the plant. When a suitable sludge has been developed a high concentration should be maintained to minimise growth of *Sphaerotilus*. The reports indicate that a low sludge content, high oxygen level, and high BOD/sludge ratio (129 g BOD/kg sludge) are likely to result in bulking of sludge. If bulking occurs, addition of chlorine to break up *Sphaerotilus* filaments together with shock loadings to cause 'explosive' growth of bacteria may bring the sludge into good condition again. Because of its destructive action, laboratory tests are needed to decide how much chlorine can be safely used. The original report should be consulted before such methods are applied.

169. An oxidation ditch contructed in 1963, operating at a loading of 17.5 lb BOD/1,000 ft$^3$ aeration channel capacity per day, and treating 410 lb BOD per day, is understood to have cost £12,000. This is equivalent to £29·2 per lb BOD per day—significantly less than the cost of an alternating double filtration plant treating 0·48 lb BOD/yd$^3$ medium day.

*Pre-fabricated aeration plants*

170. Factory built activated-sludge plants designed for operation without primary settlement of waste and for relatively long periods of aeration, have recently become available. Such plants are generally known as extended aeration plants but include, for example, plants employing the contact stabilisation process. The name 'total oxidation plants' was used at one time but is misleading since, contrary to original ideas, not all the sludge is oxidised to soluable or gaseous products. There is always an inert residue requiring disposal, although in inefficient plants much of this may be carried away in the final effluent. In such cases however it is unlikely that the effluent would conform to normal requirements in respect of suspended solids.

171. Provided that these pre-fabricated plants are not overloaded or subjected to shock loads, they can operate quite as satisfactorily as an oxidation ditch or more conventional type of plant, and it is understood that there is at least one dairy in Great Britain successfully using a plant of this type producing an effluent satisfying the requirement of the river purification board.

172. In the U.S.A., where aeration plants are relatively common, a prevalent and discouraging operational difficulty has been that the settlement tanks have not been effective in separating activated sludge from the final effluent.(34)

173. The capital and installation costs of pre-fabricated plants can be quite low, but running costs are likely to be greater than those for conventional activated sludge plants.

## Partial Treatment

174. Where dairy effluents are to be discharged to an estuary it is not normally necessary to purify them to the same high standard as for discharge to fresh-water streams, and single or two stage filtration on a coarse medium with

high-rate recirculation of effluent is a possible method of treatment. Such treatment may also be employed to reduce the BOD load on an existing alternating double filtration plant before discharge of waste to a sewer.

*High-rate filters*

175. The performance of some single and two stage high-rate filters are given in Tables 11 and 12. The efficiencies of the filters are high in terms of weight of BOD removed per unit volume, but the final effluents are not of the standard normally required for discharge to rivers in England and Wales.

TABLE 11

*Conditions of operation and performance of a single-stage high-rate filter (based on data from Morgan & Baumann)* (35)

| Recirculation ratio (Recirculated flow: raw flow) | 7·75 | 3·11 |
|---|---|---|
| Loading of filter | | |
| lb BOD/yd$^3$d | 1·135 | 0·67 |
| g BOD/m$^3$d | 675 | 398 |
| gal/yd$^3$d | 277 | 133 |
| l/m$^3$d | 165 | 79 |
| BOD (mg/l) | | |
| Raw waste | 3,270 | 1,350 |
| Final effluent | 110 | 50 |

TABLE 12

*Conditions of operation and performance of two plants employing two-stage high-rate filtration with recirculation*

| Plant | A | | | B | |
|---|---|---|---|---|---|
| Reference | Morgan & Baumann(35) | | | Trebler & Harding(36) | |
| Recirculation ratio | | | | | |
| Primary filter | 1·59 | 3·28 | 5·4 | — | — |
| Secondary filter | 3·0 | 5·63 | 8·9 | — | — |
| BOD loading of two filters together | | | | | |
| (lb/yd$^3$d) | 1·98 | 2·1 | 1·02 | 1·93 | 1·0 |
| (g/m$^3$d) | 1,180 | 1,250 | 606 | 1,150 | 595 |
| Volumetric loading | | | | | |
| Primary filter (gal/yd$^3$d) | 1,080 | 1,080 | 1,080 | — | — |
| (l/m$^3$d) | 6,430 | 6,430 | 6,430 | — | — |
| Secondary filter (gal/yd$^3$d) | 1,670 | 1,670 | 1,670 | — | — |
| (l/m$^3$d) | 9,950 | 9,950 | 9,950 | — | — |
| BOD (mg/l) | | | | | |
| Raw waste | 1,190 | 1,620 | 1,080 | 770 | 740 |
| Inflow to primary filter | 445 | 450 | 210 | — | — |
| Inflow to secondary filter | 240 | 190 | 85 | — | — |
| Final effluent | 140 | 75 | 30 | 95 | 59 |

176. Some of the newly developed plastic filter media are particularly suitable for a high-rate filter since they have a large void space relative to their effective surface area.

177. The Water Pollution Research Laboratory has compared the performance of two 7 ft deep pilot-scale filters, one containing a 2-in granite medium, and the other a fabricated plastic sheet medium. Reconstituted skimmed milk, prepared from spray dried powder, was used to simulate a dairy waste and was applied to each filter at a rate equivalent to 200 gal/yd$^3$d, without recirculation. The strength of the milk waste was increased gradually, during successive monthly periods, from a BOD of about 900 mg/l to one of nearly 2,000 mg/l. Although the specific surface area of both types of medium was the same (25 ft$^2$/ft$^3$), the granite medium initially produced the better quality effluent (Table 13); as the loading increased, however, the efficiency of removal of BOD in the two filters became comparable.

TABLE 13

*Comparison of the performance of granite and plastic media treating simulated milk waste*

(Rate of application of waste 200 gal/yd$^3$d)

| Monthly period | BOD | | | | | | |
|---|---|---|---|---|---|---|---|
| | Milk waste (mg/l) | Loading | | Settled effluent | | | |
| | | lb/yd$^3$d | kg/m$^3$d | Granite medium | | Plastic medium | |
| | | | | mg/l | per cent removed | mg/l | per cent removed |
| 1 | 927 | 1·85 | 1·10 | 161 | 82 | 427 | 54 |
| 2 | 1,060 | 2·12 | 1·26 | 188 | 82 | 270 | 74·5 |
| 3 | 1,215 | 2·43 | 1·45 | 371 | 82 | 450 | 63 |
| 4 | 1,420 | 2·84 | 1·69 | 544 | 62 | 495 | 65 |
| 5 | 1,930 | 3·86 | 2·30 | 787 | 60 | 803 | 58 |

178. The granite medium accumulated considerable quantities of biological film, and at the higher loadings soon approached the condition of ponding which would, in practice, cause serious difficulties. In contrast, the plastic medium, with almost twice the proportion of void space, showed a much smaller accumulation of film, and was never in danger of blocking. This indicates the practical advantages of the plastic medium under the rather severe conditions of loading employed.

179. Subsequently a 24·5 ft deep filter tower containing the same type of plastics sheet medium was operated at different loadings on a solution of reconstructed skimmed milk to simulate a dairy waste. The conditions of operation and the mean performance of the filter tower over a period of 14 months are shown in Table 14. It can be seen that when the filter was heavily loaded it removed up to 2·74 lb BOD yd$^3$d (1·63 kg/m$^3$d).

### *Contact stabilisation*

180. The contact stabilisation process differs from other processes using activated-sludge in that the waste water is aerated for only a relatively short period in contact with the activated-sludge. This is then removed by settlement and re-aerated for a relatively long period before it is recycled to mix again with further quantities of waste (Fig. 7).

## TABLE 14

*Conditions of operation and average performance of a 24·5 ft. (7·4 m) filter tower containing plastics medium when fed with a solution of reconstituted skim milk to simulate a dairy waste*

| Period (inclusive) | Volumetric loading | | | | BOD | | | BOD loading | | | | Suspended solids (mg/l) | | Weight of sludge produced per unit weight of BOD removed | Specific resistance of sludge to filtration ($s^2/g$ at 500 $g/cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | gal/$yd^3$d | gal/$yd^2$d | $m^3/m^3$d | $m^3/m^2$d | Milk waste (mg/l) | Settled effluent (mg/l) | Removal (per cent) | (lb/$yd^3$d) | | (kg/$m^3$d) | | | | | |
| | | | | | | | | Applied | Re-moved | Applied | Re-moved | Filter effluent | Settled effluent | | |
| Aug–Oct | (1) 202 | 1,650 | 1·2 | 8·9 | 1,590 | 548 | 65·5 | 3·17 | 2·08 | 1·89 | 1·24 | 280 | 123 | 0·15 | 195 |
| Nov–Dec | (1) 404 | 3,300 | 2·4 | 17·8 | 768 | 279 | 63·7 | 3·07 | 1·96 | 1·83 | 1·17 | 184 | 65 | 0·27 | 117 |
| Jan–Feb | (1) 605 | 4,940 | 3·6 | 26·7 | 506 | 234 | 53·8 | 3·06 | 1·64 | 1·82 | 0·98 | 129 | 58 | 0·26 | 71 |
| Feb–May | (1) 605 | 4,940 | 3·6 | 26·7 | 1,225 | 771 | 37·0 | 7·41 | 2·74 | 4·41 | 1·63 | 244 | 111 | 0·29 | 157 |
| June–July | (2) 605 | 4,940 | 3·6 | 26·7 | 1,042 | 614 | 41·2 | 6·30 | 2·58 | 3·75 | 1·54 | 286 | 123 | 0·38 | 152 |
| Aug–Sept | (2)605+605* | 9,880 | 3·6+3·6 | 53·4 | 1,100 | 647 | 41·0 | 6·65 | 2·72 | 3·96 | 1·62 | 275 | 190 | 0·38 | 112 |

*1 volume milk waste + 1 volume recirculated settled filter effluent
(1) Interval between successive applications of liquid to filter 3·2 minutes. Period of application about 1 min.
(2) Interval between successive applications of liquid to filter 1·6 minutes. Period of application about ½ min.

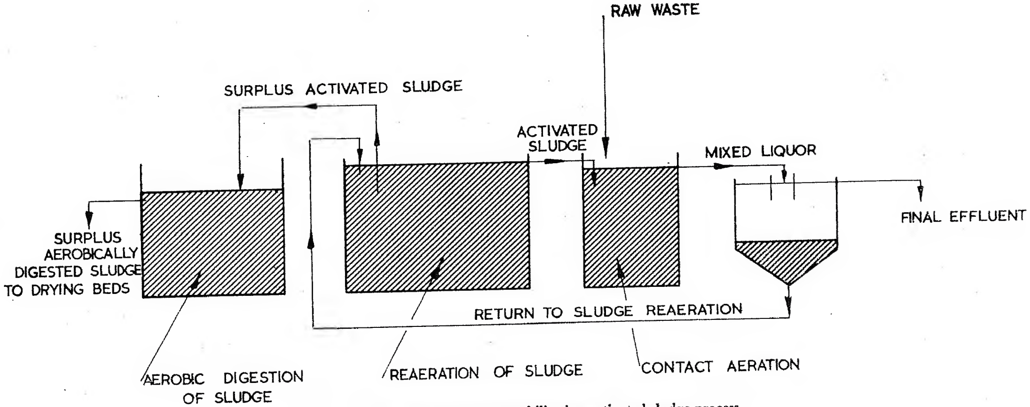

Fig. 7. Flow diagram of contact-stabilisation activated-sludge process.

181. A pilot-scale investigation of the process was carried out by the Water Pollution Research Laboratory, in collaboration with a dairy company, for partial treatment of waste waters from the production of powdered and sweetened condensed milk. The object was to decide whether the process could be used to reduce the BOD of the waste waters from 1,500 mg/l to about 500 mg/l so that an increased volume could be treated at a nearby sewage works.

182. When the plant was operated with a loading of about 155 lb BOD per 1,000 ft$^3$ contact plus aeration capacity per day (2·48 kg/m$^3$d) the corresponding volumetric loading being 10,300 gal/1,000 ft$^3$d (1,650 l/m$^3$d), difficulty was soon experienced with bulking of the activated-sludge. A reduction of the BOD load to one third prevented further deterioration of the settlement characteristics of the sludge, but on increasing the load to the original value serious bulking again occurred.

183. Subsequently the flow was increased threefold to 31,300 gal/1,000 ft$^3$d (5,000 l/m$^3$d), raising the BOD loading to 470 lb/1,000 ft$^3$d (7,550 g/m$^3$d). These values corresponded to a contact time of 1·6 h, based on the flow of waste water, and a sludge re-aerated time of 3·1 h. The concentration of activated-sludge in the mixed liquor was about 8,000 mg/l and the sludge loading was thus about 0·57 lb per day per lb solids in the contact and re-aeration tanks. Under these operating conditions the sludge-volume index decreased to a value in the range 50–100 ml/g d indicating that the sludge was dense and settled rapidly. Over a period of 2 months the BOD of the milk waste was reduced from about 1,500 mg/l to about 500 mg/l. In a subsequent 4-month period the rate of flow of waste water to the plant was varied daily in a predetermined pattern to simulate the variation in the rate of flow from the factory. Satisfactory results were maintained.

*Chemical coagulation*

184. Treatment with aluminoferric (about 500 mg/l) and lime followed by settlement, will reduce the BOD of milk washings by up to 85 per cent(25). The clarified liquid can then be further treated by single filtration. At a plant visited by the Water Pollution Research Laboratory, 300 mg aluminoferric was used per litre of waste. After settlement, the liquid was treated at a loading of 0·24 lb BOD/yd$^3$ (143 g/m$^3$d). The effluent had a BOD of 14 mg/l(28).

185. Treatment with a coagulant is relatively costly and gives rise to a large volume of watery sludge which, because of its aluminium content, is unsuitable for disposal on cultivated land.

*Aerobic fermentation (Scarlett's process)*

186. During work for the Water Pollution Research Board it was observed that if washings containing 1 per cent milk were allowed to ferment at a temperature of 30°C (86°F) for 1 day they could subsequently be treated at a loading of 100 gal/yd$^3$d on single percolating filters to produce an effluent having a BOD of not more than 20 mg/l(25) without clogging of the filter. Washings which had not been allowed to ferment soon brought about choking of the filter under similar conditions of loading.

187. This basic idea was developed by Scarlett(29) who suggested heating and aerating the milk washings to encourage lactic fermentation and avoid

production of offensive odours. The process is illustrated in Fig. 8. A number of full-scale plants have been built,(37) and when operated under design conditions give effluent of consistently good quality.

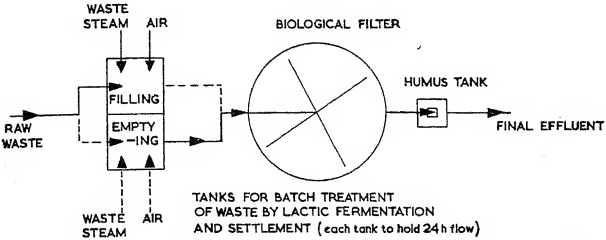
WASTE STEAM
AIR
BIOLOGICAL FILTER
HUMUS TANK
FILLING
EMPTY-ING
RAW WASTE
FINAL EFFLUENT
WASTE STEAM
AIR
TANKS FOR BATCH TREATMENT OF WASTE BY LACTIC FERMENTATION AND SETTLEMENT (each tank to hold 24 h flow)

Fig. 8. Flow diagram of Mr. Scarlett's process involving preliminary coagulation by aerobic lactic fermentation and settlement.

## Disposal of Sludges

188. The preliminary settlement of the waste waters and the various methods of biological treatment described give rise to watery sludges which require disposal.

189. It is usual for primary, humus and surplus activated-sludges to be dewatered on drying-beds before final disposal on land.

190. The sludges can be de-watered on filter presses but it is normally necessary first to 'condition' the sludge with chemical coagulant. For this purpose aluminium chlorohydrate added in a concentration of about 2 per cent (as $Al_2O_3$) on dry weight of solids may be used.

191. Some information on costs of disposal of sewage sludges is given in Table 15.

TABLE 15

*Costs of sludge disposal (inclusive of loan charges on capital work) From Townend* (38)

| | *Cost per ton dry solids* (shillings) |
|---|---|
| (a) *Dumping without utilization* | |
| Pumping to permanent lagoons for drying in situ | 10–15 |
| Pumping to land and ploughing in (non agricultural) | 30 |
| Boating to sea | 60 |
| (b) *Disposal with utilization* | |
| Pumping to agricultural land | 25–30 |
| Air drying on earth plots | 30 |
| Air drying on beds | 60 |
| Filter pressing with lime to 60 per cent water | 80–100 |
| Heat drying of press cake to 10 per cent water | 140–200 |
| Vacuum filtration and flash drying | 400 |

## Spray Disposal on Grassland

192. Spray disposal of dairy effluent is used in parts of the United States(39) and to some extent in New Zealand(40) and Holland(41). A useful description of practice in New Zealand is given in a booklet by McDowell and Thomas(40).

193. In Great Britain spraying may be of value in dealing with the extra volumes of washings during the flush season in late spring and early summer but cannot be used during prolonged periods of frosty weather and is therefore not suitable by itself as a method of disposal.

194. It has been emphasised in Chapter 2 that strong liquids such as whey should be used for animal feeding and not discharged as waste water. However, in emergencies, liquid, such as whey, may sometimes be disposed of by tanker on to grassland.

195. Dilute washings cannot be distributed economically from tankers. With these it is therefore necessary to have a suitable area of grassland near the factory to which waste may be conveyed by pumping.

### *Choosing a site*

196. Care must be taken to choose a site so that there is no nuisance from odours and wind-borne spray.

197. If the waste waters are distributed by spraying before they become septic there will not normally be any odour nuisance on the leeward side of the irrigation sprays. Nevertheless, since droplets of atomised liquid can be carried by strong winds over considerable distances, care should be taken to avoid spraying on the windward side of dwellings or public places, unless these are protected by a thick belt of trees. In Great Britain wind direction frequently changes and provision should be made to discontinue spraying when conditions might lead to trouble. Similar considerations must govern the choice of site in relation to the factory. Air-borne droplets have been suggested as a cause of difficulties with bacteriophage in the cheese making industry.

198. It is an advantage if the site is at a lower level than the factory since this can reduce the cost of pumping; gravity flow or smaller pipes or both may then be possible.

199. The site selected should preferably be flat or only slightly sloping (gradient less than 1 in 17) so as to avoid uneven distribution of liquid and excessive run-off, ponding, etc.

200. The soil should preferably be coarse and well drained but with such soils, and especially in the vicinity of wells, care must be taken to avoid contamination of ground water. A highly plastic clay soil may be quite unsuitable for irrigation but some heavy soils may give satisfactory results. The permeability of a soil is best measured by a two-ring infiltrometer test, measurements being made at a number of positions. Such measurement can give a guide to the rate of application that might be possible but allowance must be made for the slope of the site, rainfall, density of cover crop, and possible harmful effects of the waste on soil structure.

201. A cover crop is necessary to prevent compacting the soil by droplets of water with consequent sealing of the surface. A well established field is better than a newly grassed area(42).

202. Account must be taken of the possibility of run-off during periods of heavy rain giving rise to contamination of streams used as a source of water supply.

203. The area of land required will depend on the volume, strength, and other characteristics of the waste. It is a mistake to provide too small an area in the first instance.

204. It is recommended that the advice of a soil chemist be sought.

*Rate of application of liquid*

205. The system of applying waste water to the irrigation area can be varied by varying the rate of application (inches water per hour), by varying the total volume applied per dose, or by varying the rest period between applications. The conditions must be selected to avoid scorching of the cover crop, local ponding, putrefaction, and run-off.

206. After each period of irrigation it is necessary to allow a sufficiently long rest period to avoid scorching the pasture, to allow time for growth of vegetation and grazing by stock, to permit destruction in the soil of organic matter from the waste, and possibly to allow time for dissipation or destruction of any pathogenic organisms. For most situations a minimum rest period of 14 days is suggested.

207. The maximum rate of application of liquid will vary from site to site. As a guide however it may be assumed that it would not normally be satisfactory to apply more than the equivalent of 1 in depth of liquid during a 24 h period and that following this application no further liquid would be applied for 14 days. This is equivalent to a mean rate of application of about 1,600 gal/acre day or 26 in per year. On clay soils the maximum rate of application would be much less, probably as little as one quarter of the above rate, and in wet weather it would not be possible to apply any liquid without danger of run-off.

*Type of sprinkler*

208. A sprinkler with a high rate of discharge is less liable to become blocked by foreign matter or particles of curd than a low-pressure sprinkler. There is however the disadvantage with the high pressure type that pumping costs are greater and since the liquid discharge remains for a longer time in the air the spray is much more seriously affected by wind. It is probably best to employ low pressure sprinklers of the impulse-reaction type made of brass or bronze.

209. The design of the sprinkler system is not important so far as the basic principles of the method are concerned but detailed information is available from a number of sources(40)(43).

*Pre-treatment of wastes*

210. Wastes for disposal by spray irrigation should be passed through a grease trap to remove fat and through fine screens to remove curd and foreign bodies which can cause blockage of sprays. A flow-equalising tank or holding tank is necessary and can serve as the feed tank to the irrigation pump. The tank should preferably be large enough to allow continuous discharge of wastes throughout the day but it should not be so large as to permit the waste to become septic.

211. Portland cement is attacked by acidic dairy effluent and tanks should preferably be of acid-resistant material. Mild-steel tanks may be suitable if the waste is not too acid but are best coated with epoxy resin paint. There is information on materials resistant to dairy effluents in the report of the Dairy Floors Sub-Committee(44).

212. Centrifugal pumps are preferred to piston-type pumps.

213. Pipes of galvanised iron, aluminium, steel, or asbestos cement are liable to corrosion by acidic wastes. Bitumen-coated pipes may be affected by high temperatures and by fat. Polythene pipes, if used, should be buried. In many installations aluminium pipes are understood to give satisfactory service.

*Effect on soil and cover crop*

214. In relatively dry areas when strong wastes such as whey are disposed of by spray irrigation the volume of water present in the waste will generally be insufficient to increase that falling as rain to the optimum for good pasture growth and it may be an advantage to dilute the waste. However, where whey is fed to animals such a situation should not normally arise.

215. The more dilute wastes may affect the soil and cover crop on account of the inorganic salts they may contain (as a result of cleaning operations in the factory), or on account of their organic content.

216. An excess of sodium in water applied to a soil causes disintegration of the soil granules, as a result of ion-exchange reactions, and a deterioration of the physical condition of the soil. The amount of sodium in water used for irrigation, expressed as a percentage in equivalents of the total soluble cations present, i.e., $100\ \mathrm{Na}/(\mathrm{Ca} + \mathrm{Mg} + \mathrm{Na} + \mathrm{K})$ should not be greater than 80 and the total concentration of cations in milli-equivalents per litre should not exceed 25(45). Figures reported for milk range from 17 to 23 per cent, and dilutions of milk or whey would not therefore be expected to cause deterioration of soil structure. However, the sodium content of mixed effluent may be considerably increased by salt and by alkaline detergents. To some extent the effects of sodium in a waste can be counteracted by the use of lime(46).

217. Other mineral constituents have a potential fertilising value; phosphate and potash are perhaps most important in this respect.

218. The nitrogen present in 1,000 gal skimmed milk is reported to be equivalent to 265 lb ammonium sulphate and that present in 1,000 gal cheese whey

equivalent to 60–64 lb ammonium suplphate. The nitrogen content of dry solids from skimmed milk and whey is about 5·2 and 2·4 per cent respectively and exceed the value (1·5 per cent) below which nitrogen starvation of the soil might occur(47). Dairy effluent would therefore be expected to have a positive fertilising value.

219. The application of dairy effluent to soil initially causes a decrease in pH value owing to the formation or presence of organic acids. As these acids are broken down and calcium and other mineral substances are set free the pH value rises again, to a value usually higher than the initial one.

220. Hot liquids can harm the cover crop and cooling should be encouraged by mixing hot liquids with cold ones. Elevating the sprays also helps cooling.

221. According to McDowell and Thomas, bare poorly covered ground will not give satisfactory absorption of sprayed wastes even when the soil is quite sandy. The falling droplets fracture the soil granules and finer particles rise to the surface and practically seal off the subsoil from entry of liquid. For dairy wastes the most suitable and effective cover crop is said to be pasture grass. Opinion differs as to whether the grasses should be shallow rooted or deep rooted(48)(49).

222. The general observation in New Zealand is that irrigation with dairy waste encourages the growth of coarser grasses at the expense of the finer ones. It also extends the growing period and rate of recovery of grass after it has been grazed during normally slow growing periods. The growth is said to be palatable to stock.

223. It is usually found most convenient to graze or harvest the grass ahead of spraying and then allow 10 days for recovery before spraying is begun. If a 14 day rest period after irrigation were allowed this means irrigation on about a 25 day cycle.

224. Reports from Holland(43) indicate that a rate of application of 850 mm (33·4 in.) liquid per year to a sandy soil was too high and led to swampy conditions and a deterioration in the yield and quality of grass. Application of 400–500 mm (16–20 in.) liquid per year on peaty soil and 200–300 mm (8–13 in.) per year on sandy soil led to a high yield and improvement in quality although the mineral composition of the grass became less favourable partly because of disappearance of clovers and other herbs. The ratio K/(Ca + Mg) expressed in milli-equivalents exceeded 2·2—a condition such that the grass tetany hazard was high. The earth alkalinity (Ca + Mg − P) fell below the level necessary to avoid bone defects in dairy cattle. The excess base (K + Na + Ca + Mg − Cl − P − S) was also too low, which may lead to acid urine or haemoglobinurea. It is reported however that these effects were not the inevitable result of irrigation with dairy effluent but the result of incorrect (too high) dosage leading to far too great a supply of potassium and phosphorus.

*Costs*

225. As examples of costs McDowell quotes the following figures based on prices in 1960:

1. For disposal of 10,000 gal/day dilute wastes through a pipeline 1,000 ft long.

   Cost of equipment £1,375

2. For disposal daily of 50,000 gal waste containing 21,000 gal whey. Irrigation site ½ mile from factory and at level 30 ft higher than factory.

   Cost of equipment £8,000

226. Labour requirements are said to be about ⅔ to 1 man/hour per acre per irrigation cycle. In addition to the above there is the cost of pumping to consider.

## CHAPTER 6

# Summary and Conclusions

*Summary*

227. The problems arising from the disposal of dairy effluents have been reviewed and consideration given to the many and varied aspects involved.

These include:

(i) A survey of the law relating to effluents and effluent disposal, the development of legislation covering this field and the present position. (Paras. 12–29).

(ii) Problems of effluent control, sources of waste water and materials and estimation of losses involved. (Paras. 30–35).

(iii) Measurement and sampling of effluent together with the instruments which are desirable and which are available and analyses of results obtained. (Paras. 36–44).

(iv) Possibility of reducing the losses caused both by residues in plant and by processing wastage of surplus by-products. (Paras. 45–47).

(v) Variation in losses occurring in different types of plants. (Para. 48).

(vi) Reducing detergent load in effluent and savings in water usuage. (Paras. 49–56).

(vii) Discharge of dairy effluent to sewers and special problems involved. (Paras. 57–66).

(viii) Pre-treatment of effluent and conditions laid down by local authorities together with rights of dairy in cases of dispute. (Paras. 67–70, 75–80).

(ix) Present situation throughout the country regarding effluent disposal as revealed by returns to a questionnaire. (Paras. 71–74).

(x) Costs incurred by local authorities in receiving trade effluent and charges imposed by local authorities on dairies in respect of treatment of dairy effluent as revealed by questionnaire. (Paras. 81–101).

(xi) Discharge of effluent to water courses, effect of effluent on streams. (Paras. 102–107).

(xii) Special problems of dairy effluent, treatment required and standards imposed. (Paras. 108–125).

(xiii) Costs of operating treatment plants to meet standards fixed by river authorities. (Paras. 126–132).

(xiv) Various methods of effluent treatment and disposal including irrigation. (Paras. 133–226).

*Disposal to public sewer*

228. Dairies, by the nature of their operations, produce waste water which must be disposed of as soon as possible and the easiest and most satisfactory way of doing so is by discharge to the local sewer. This can be done with the consent of the local authority subject to such conditions—including a financial contribution—as it may require.

229. The conditions are mainly to prevent damage to the sewers and overloading or disruption of the sewage treatment system and there can be no objection to a reasonable charge for the use of the sewer and the additional cost of treatment. It is for individual dairies to negotiate acceptable terms with the local authority. The charge demanded will depend on the many local factors involved. Dairies are therefore advised to discuss their problems with the local authority at an early stage so that a mutually acceptable agreement can be reached. Whatever the outcome, the effect should be to encourage the dairy to reduce wastage and exercise whatever control it can to reduce the volume and strength of its effluent.

230. The first objective should obviously be to eliminate losses at source. Where this cannot be done completely, it should be the aim to recover as much waste material as possible in a form that can be used in one way or another. Milk solids lost generally result from spillage (particularly from churns), residues in plant, processing losses and wastage of surplus by-products. The first of these can generally be prevented by good plant design and layout and good management; the second by careful draining and rinsing of equipment using limited quantities of water. Processing losses may be difficult to prevent but with modern equipment and good management it should be possible to reduce them to a minimum and to prevent wastage of surplus by-products.

231. In-place cleaning should be used wherever possible as this causes less damage to piping and fittings with consequent less leakages. It also economises on detergents and water and results in cleaner and drier floors. Conservation of used detergent solutions is also recommended as they can be topped up and re-used. It is however stressed that conservation measures need adequate and continual attention from both management and staff. Water saving both by prevention of actual wastage and the re-use of suitable waste water is recommended. Ways in which these things can be done are by fitting every water hose with automatic shut-off valves, and by re-using cooling water. The net result should be a smaller volume of effluent of lower strength with a saving in overall costs to the dairy.

232. As has already been indicated disposal of effluent by discharge to a local sewer is probably the best and cheapest way in the long run despite what may appear to be the high charges levied by the local authority.

*Disposal to water courses*

233. Where disposal to a sewer is not practicable and the effluent has to be discharged to a watercourse then the erection of a treatment plant by the dairy is inevitable. Before an effluent can be discharged to a watercourse, the consent of the river authority must be obtained. The authority is entitled to attach such conditions to the consent regarding the nature and conformation of the effluent, its temperature, maximum rate of flow and quantity to be discharged daily, as it considers reasonable. Where such a discharge is contemplated, an early approach to the river authority with plans of the proposed treatment plant is advisable. All treatment plants are costly and require a considerable area of land whether they involve biological filtration, aerobic fermentation, activated-sludge or simply aeration. In addition there are running costs, as

well as labour and maintenance, and these are continually increasing items of expenditure. To some extent, the type, strength and volume of effluent may decide the method of treatment to be employed.

234. The alternating double filtration(ADF) system, if of adequate capacity and operated efficiently, can cope with variations in volume and strength to some extent and will normally give an effluent that would comply with the standards set by most river boards.

235. The activated-sludge process is more sensitive to variations in strength and rate of flow and therefore needs holding tanks of adequate capacity to balance the strength and rate of flow of the waste. Nevertheless it is probable that such a plant could be designed to produce a satisfactory effluent more cheaply than an ADF plant. The area of land required and the capital cost of the plant is less than for the ADF system but the running costs would be higher and skilled supervision and maintenance is essential.

236. Pre-fabricated aeration plants or factory built activated-sludge plants are now available and capital and installation costs are relatively low, although their running costs are said to be high—higher even than for conventional activated-sludge plants. The nature of the activated-sludge produced is such that sometimes it is slow in settling out and in consequence the final effluent may not always satisfy the high standard of some river authorities in respect of suspended solids.

237. The oxidation ditch or Pasveer ditch is essentially a cheaply constructed form of activated-sludge plant and because of its robust nature can deal with some types of dairy waste more reliably than the conventional type of activated-sludge plant. Its capital cost is very low—about half that of a conventional plant—but maintenance costs are high.

238. In country areas where land is available at relatively low cost disposal of effluent by irrigation may have advantages. The type of soil is important. It should preferably be of a coarse nature and well drained although some heavy soils may be suitable provided they are not highly plastic clay soils. A cover crop is necessary and a well established grass is better than a new ley. The rate of application should not exceed the equivalent of 1 in. of rain in 24 hours and no further liquid should be applied for the next 14 days. This is equivalent to 22,000 gallons of effluent per acre per fortnight. On heavy soils the rate of application should only be about a quarter of this. Irrigation with dairy waste in this way is claimed to encourage the growth of coarser grasses at the expense of the finer ones and to extend the growing period as well as increasing the rate of recovery of the grass after it has been grazed during a normally slow growing period. The grass is claimed to be palatable to stock. Holding tanks, and irrigation equipment as well as the necessary area of land will be required but the cost of these should be less than that of a treatment plant.

239. All the factors involved such as situation of the dairy, the availability and cost of land, operations carried out, type of effluent to be treated, initial cost of various types of treatment plants, their advantages and disadvantages, main-

tenance and running costs and the standards imposed by the river authorities on the final effluent must all be carefully considered before a final decision on the type of treatment plant to be installed can be taken.

*Conclusions*

1. Dairies should take all steps possible to reduce wastage to a minimum by good plant design and layout and efficient management.
2. Where facilities are available dairies are advised to discharge their effluent to the sewer as this is probably the best and cheapest method of disposal in the long run.
3. Charges levied on dairies by local authorities for the reception and treatment of their effluent vary widely. It is therefore wise for dairymen to discuss fully with their local authorities what the charges will be and how they would be made up.
4. No charge is levied in respect of the discharge to a water course but dairymen should bear in mind the cost of erection of a treatment plant as well as its maintenance and running costs.

# Appendix I

## (1937 Exempt Discharge)
## (LOCAL AUTHORITY)

### Public Health (Drainage of Trade Premises) Act, 1937
### Public Health Act, 1961
### Notice of Direction

To or other the Owner and to or other the

occupier of the premises known as

WHEREAS

(1) Trade effluent is now discharged from the premises known as

and situate at

(hereinafter referred to as "said premises")

into the public sewer situate in

in the

(2) Such discharge is one to which Sections 55 and 57 of the Public Health Act, 1961 apply.

(3) [i](on the day of 19 , the

being an interested body as defined in Section 14(1) of the Public Health (Drainage of Trade Premises) Act, 1937, signified their approval to the issue of this direction, in accordance with the provisions of Sections 55(4) and 57(3) of the Public Health Act, 1961.)

NOW THEREFORE

(hereinafter called "the Authority")
[i](with the approval of the said

) HEREBY GIVE NOTICE OF THEIR DIRECTION

THAT as from the [ii]the said discharge

shall be subject to the following conditions:

---

[i] Delete if inappropriate.

[ii] Not less than two months from the date hereof.

Payment

1. The occupier of the said premises shall pay to the Authority on demand for every thousand gallons of trade effluent discharged into the said public sewer during each half year ending 31st March and 30th September the sum of d calculated in accordance with the provisions contained in the Appendix hereto

Temperature

2. No trade effluent shall be discharged which has a temperature higher than 110° Fahrenheit.

pH Value

3. No trade effluent shall be discharged the pH value of which is less than or greater than

Inspection

4. (1) An inspection chamber or manhole shall be provided and maintained by the owner or occupier in a suitable position in connection with each pipe through which the trade effluent is so discharged, and such inspection chamber or manhole shall be so contructed and maintained by the owner or occupier as to enable a person readily to obtain samples of the trade effluent so discharged.

Measurement and determination of discharge

(2) a notch gauge and continuous recorder or some other apparatus suitable and adequate for measuring and automatically recording the volume and rate of discharge of trade effluent so discharged shall be provided and maintained by the owner or occupier in connection with every such pipe to the reasonable satisfaction of the Authority.

(3) Records shall be kept of the volume and rate of discharge of trade effluent discharged into the sewer at all times available for inspection by any authorised officer of the Authority and copies of such records shall be send to the Authority on demand.

(4) The foregoing provisions of this condition shall be of no effect so long as there is provided and maintained to the satisfaction of the Authority some other method approved by the Authority of sampling the trade effluent or of determining the volume and rate of discharge of trade effluent so discharged.

Dated this day of 19 .

for and on behalf of the Authority

Signed ......................................

NOTE Your attention is drawn to the right of appeal to the Minister of Housing and Local Government conferred by subsection (6) of Section 55 and subsection (5) of Section 57 of the Public Health Act, 1961, both of which subsections read as follows:

> "The owner or occupier of the trade premises may within two months of the giving of the notice to him or with the written permission of the local authority at any later time appeal to the Minister agaister against the direction."

## APPENDIX REFERRED TO IN CONDITION NO. 1 OF THIS NOTICE OF DIRECTION

The charge specified in Condition 1. of this Notice of Direction which has been based on the actual cost of reception treatment and disposal regard being had to the provisions of Section 55(2) of the Public Health Act, 1961, is calculated as follows: (1)

---

(1)Specify method of calculation of charge.

## (Mixed 1937 Exempt Discharge and pre-1961 Discharge)
## (LOCAL AUTHORITY)

### Public Health (Drainage of Trade Premises) Act, 1937
### Public Health Act, 1961
### Notice of Direction

To or other the owner and to or other

the occupier of the premises known as

WHEREAS

(1) Trade effluent is now discharged from the premises known as

and situate at

(hereinafter referred to as

"the said premises") into the public sewer in

in the

(2) Sections 55 and 57 of the Public Health Act, 1961, apply to part of such discharge.

(3) (i)(on the day of 19 . the

being an interested body as defined in Section 14(1) of the Public Health (Drainage of Trade Premises) Act, 1937, signified their approval to the issue of this direction, in accordance with the provisions of Sections 55(4) and 57(3) of the Public Health Act, 1961)

NOW THEREFORE THE

(Hereinafter called "the Authority".)(i)

(with the approval of the said )

HEREBY GIVE NOTICE OF THEIR DIRECTION

that as from the (ii)such part of the trade effluent discharged under the Authority's consent to discharge trade effluent

from the said premises dated which was previously exempt from payment under the provisions of Sections 4 and 5(2) of the Public Health (Drainage of Trade Premises) Act, 1937 shall be subject in all respects to the conditions contained in the said consent as modified by any subsequent directions given under Section 60 of the Public Health Act, 1961, except those relating to payment of charges to the Authority, and the occupier of the said premises shall pay to the Authority on demand for every thousand gallons of such previously exempted part of the trade effluent discharged into the public sewer during each half year ending 31st March and 30th September the sum of d calculated in accordance with the provisions contained in the Appendix hereto.

---

(i) Delete if inappropriate.

(ii) Not less than two months from the date hereof.

Dated this day of 19 .

For and on behalf of the Authority

Signed ......................................

NOTE Your attention is drawn to the right of appeal to the Minister of Housing and Local Government conferred by subsection (6) of Section 55 and subsection (5) of Section 57 of the Public Health Act, 1961, both of which subsections read as follows:

> "The owner or occupier of the trade premises may within two months of the giving of the notice to him or with the written permission of the local authority at any later time appeal to the Minister against the direction."

## Appendix referred to in this Notice of Direction

The charge specified in Condition 1 of this Notice of Direction which has been based on the actual cost of reception treatment and disposal regard being had to the provisions of Section 55(2) of the Public Health Act, 1961 is calculated as follows: (1)

---

(1) Specify method of calculation of charge.

## (Post 1961 Consent)
## (LOCAL AUTHORITY)

### Public Health (Drainage of Trade Premises) Act, 1937
### Public Health Act, 1961
### Consent to the Discharge of Trade Effluent

WHEREAS

(1) whose registered office is situate at/of

is/are the occupier(s)/owner(s) of the

trade premises situate at

and by a Trade Effluent Notice

dated the day of One thousand nine hundred and

has/have requested the

(hereinafter referred to as "the Authority") to consent to the discharge of trade effluent by him/her/them from the said trade premises into the sewers of the Authority

(2) (i)(On the day of 19 the being an interested body as defined in Section 14(1) of the Public Health (Drainage of Trade Premises) Act, 1937, signified their approval to the issue of this consent, in accordance with the provisions of Section 2(4) of the last mentioned Act.)

(3) The nature or composition of the trade effluent (hereinafter called "the trade effluent") to be discharged under this Consent is specified

in the said Notice in manner following, that is to say: (ii)

NOW THEREFORE in exercise of the powers conferred upon them in that behalf by the Public Health (Drainage of Trade Premises) Act, 1937 and the Public Health Act, 1961, the Authority with the approval of the said (i)

) HEREBY CONSENT

to the discharge of trade effluent from the said premises into their sewers subject to the following conditions, that is to say:

| | |
|---|---|
| Sewer affected | 1. The sewer(s) into which the trade effluent may be discharged is/are the sewer(s) situate at the points shown in the schedule (plan) attached hereto in the |

---

(i)Delete if inappropriate.

(ii)Specify nature and composition of effluent.

**Maximum amount to be in any day**

2. The maximum amount of the trade effluent discharged on any one day of twenty-four hours determined from midnight to midnight shall not exceed gallons without the written consent of the Authority

**Maximum rate of discharge**

3. The highest rate at which the trade effluent may be discharged shall not exceed gallons per hour

**Matters to be eliminated prior to discharge to the sewer**

4. There shall be eliminated from the trade effluent before it is discharged into the sewers of the Authority the following matters, that is to say:

Any other matters likely to injure the said sewers or to interfere with the free flow of their contents or to affect prejudicially the treatment and disposal of their contents

**Temperature**

5. No trade effluent shall be discharged which has a temperature higher than 110°F

**pH Value**

6. No trade effluent shall be discharged the pH value of which is less than or greater than

**Condensing Water**

7. No condensing water shall be discharged

**Payment**

8. Payment shall be made to the Authority as the rate of for every thousand gallons of trade effluent discharged into the sewers of the Authority

All sums payable to the Authority under this condition shall become due and payable on demand

**Inspection Chamber**

9. (i) An inspection chamber or manhole shall be provided and maintained by the owner or occupier in a suitable position in connection with each pipe through which the trade effluent is so discharged, and such inspection chamber or manhole shall be so constructed and maintained so as to enable a person readily to obtain samples of the trade effluent so discharged

**Measurement and determination of discharge**

(ii) A notch gauge and continuous recorder or some other apparatus suitable and adequate for measuring and automatically recording the volume of the trade effluent so discharged shall be provided and maintained in connection with every such pipe

(iii) There shall be provided maintained and tested to the satisfaction of the Authority on connection with every such pipe apparatus capable of accurately determining measuring and recording the nature and composition of the trade effluent discharged

(iv) Records shall be kept of the volume rate nature and composition of the trade effluent discharged into the sewer at all times available for inspection by any authorised officer of the Authority and copies of such records shall be sent to the Authority on demand

(v) If the recorder or other apparatus or means of measurement and record aforesaid ceases to register or measure correctly then the quantity of the trade effluent discharged into the sewers of the Authority during the period from the date as at which the records of the volume of trade effluent discharged into the sewers were last accepted by the Authority as being correct up to the date when the recorder or other apparatus or means aforesaid again registered correctly shall for the purpose of any payment to be made to the Authority in respect of such first mentioned quantity of the trade effluent be based on the average daily volume of the trade effluent discharged during the preceding period over which the said records were last accepted as aforesaid or during the month immediately after the recorder or other apparatus or means of measurement and record aforesaid has been corrected whichever is higher.

(vi) The foregoing provisions of this condition shall be of no effect so long as there is provided and maintained to the satisfaction of the Authority some other method approved by the Authority of sampling the trade effluent or determining measuring and recording the volume rate nature and composition of trade effluent so discharged.

Signed ......................................

DATED this day of

One thousand nine hundred and

NOTE Your attention is drawn to the right of appeal to the Minister of Housing and Local Government conferred by subsection (6) of Section 55 and subsection (5) of Section 57 of the Public Health Act, 1961, both of which subsections read as follows:

> "The owner or occupier of the trade premises may within two months of the giving of the notice to him or with the written permission of the local authority at any later time appeal to the Minister against the direction."

# Appendix II

## Notes on the Mogden Formula

The Mogden Formula recognises that the cost of treatment of sewage and trade effluent can be conveniently dealt with in three steps:

(i) $V =$ Conveyance and preliminary treatment, the cost of which is roughly proportional to volume, in pence per 1,000 gallons.

(ii) $B =$ Biological treatment, essentially an oxidation factor which is related to the 'strength' of the effluent, in pence per 1,000 gallons.

(iii) $S =$ Sludge disposal which is largely proportional to the content of suspended solids in the effluent, in pence per 1,000 gallons.

If Mt and Ms are the McGowan strengths of the settled trade effluents and settled sewage respectively then the Biological Treatment factor can be expressed as:

$$\frac{Mt}{Ms}B$$

where B is a constant for any particular sewage works.

If St and Ss are the suspended solids content of trade effluent and sewage respectively, then the sludge disposal factor of the formula may be expressed as:

$$\frac{St}{Ss}S$$

where S is a constant for any particular sewage works.

Therefore the formula may be expressed as:

$$C = V + \frac{Mt}{Ms}B + \frac{St}{Ss}S$$

where C is the cost in pence per 1,000 gallons.

There are numerous modifications of this formula, notably those which use Oxygen Absorption or Biochemical Oxygen Demand figures in place of McGowan factors. In addition, some authorities have added a further factor to cover the cost of treating compounds such as those of nickel or chromium.

A full account of the Mogden Formula is contained in a paper by Griffiths and Kirkbright(50) on pps. 505–514 Journal of the Institute of Sewage Purification **1959**.

# Appendix III

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# Appendix IV

## Glossary

| | |
|---|---|
| Activated sludge process | A biological process for treatment of sewage in which the sewage is aerated for a period in the presence of a suspension of micro-organisms which feed on and thus remove its organic impurity. |
| Aerobic fermentation (lactic fermentation) | A process involving aeration of an effluent to encourage aerobic fermentation of sugars to produce lactic acid. |
| Alternating double filtration (ADF) | A biological filtration process in which the waste waters are passed through two filters in series with settlement after each filtration stage. At intervals, usually weekly, the order of the filters but not of the settlement tanks is reversed. |
| Aluminium chlorohydrate | A partially neutralised solution of aluminium chloride. |
| Alumino-ferric | A commercial form of hydrated aluminium sulphate containing a small amount of iron sulphate as an impurity. |
| Anaerobic digestion | A process in which conditions are provided for anaerobic bacteria to break down organic matter and produce methane. It is most commonly employed for treatment of sewage sludges. |
| Automatic proportional sampler | An automatic device which takes a sample of volume proportional to the rate of flow of the waste paper at the time of sampling. It may be continuous or intermittent in operation. |
| Balancing tank | A tank into which waste waters flow at varying rates and from which a mixture flows or is pumped out at a uniform rate. Such a tank also serves to lessen variations in the strength of a liquid. In some cases this may be its chief function. |
| Biochemical oxygen demand (BOD) | A measure of the quantity of dissolved oxygen which is taken up by the sample of effluent under prescribed conditions in five days at 20°C. It is expressed in units of milligrammes per litre and gives an indication of the concentration of biochemically-oxidisable organic matter present in the effluent. This is a measure of the concentration of polluting matter in the effluent. |
| BOD load | The biochemical oxygen demand expressed in units of weight. It is obtained by multiplying the BOD by the volume of waste water expressed in appropriate units. (BOD(mg/l) × volume (l) gives BOD load (mg); and BOD (mg/l or p.p.m.) × volume ($10^5$gal) gives BOD load (lb)). This is a measure of the quantity of polluting matter. |

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| Biological filtration | A biological process in which waste waters are evenly distributed over a bed of graded rock, slag, gravel or other inert medium. As the liquid percolates through the bed, bacteria and other micro-organisms growing as a slimy film supported on the surface of the medium, feed on and remove the organic impurity from the waters. |
| Biological treatment | Treatment of an effluent or waste water by a process depending on bacteria or other organisms. |
| Bulking (of activated-sludge) | A condition of activated-sludge usually due to growth of filamentous bacteria which leads to the formation of activated sludge floc of low density and large bulk, which does not settle. |
| Chemical coagulation | Treatment with chemicals such as hydrated aluminium sulphate and lime to bring about coagulation of suspended matter so that it can be subsequently removed by settlement. |
| Chemical oxygen demand | Effectively a measure of the total quantity of oxygen required to oxidise completely the organic impurities in the waste water. The test involves refluxing the sample with a mixture of sulphuric acid and a solution of potassium dichromate. |
| Contact stabilisation | A modification of the activated sludge process in which activated-sludge is re-aerated for a relatively long period before it is mixed again with the incoming waste waters. |
| Detergents | Solutions used for cleaning plant and equipment. In the dairy industry these are usually alkaline solutions but they may include solutions of synthetic organic surface-active agents. |
| Dichromate value | Another name for the chemical oxygen demand. |
| Double filtration | A process involving biological filtration in two stages in series, usually with settlement between each stage. |
| Effluent | Waste waters discharged from a factory or from a treatment plant. |
| Final effluent | The liquid finally discharged after treatment of waste waters. |
| Filtration with recirculation of effluent | A biological filtration process in which a proportion of the treated effluent is pumped back to dilute the liquid applied to the filter. |
| Flush season | The period April-July when milk production is at its maximum. |
| High-rate filtration | Biological filtration on coarse (4–6 in.) medium at high volumetric loadings to bring about partial purification of the waste waters. Purified effluent may be re-circulated at a high-rate to dilute the liquid applied to the filter. |
| Lagoon | A shallow (4 to 5 ft deep) pond through which waste waters flow and in which they are subject to biological action. |

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| McGowan strength | An estimate of the total amount of oxygen required to oxidise organic matter and ammonia in a sample of waste water, expressed as parts per 100,000 (mg/100 ml). It is calculated by multiplying the oxygen absorbed from N/8 acid permanganate by 6·5 and adding to it the concentration of ammoniacal and organic nitrogen multiplied by 4·5. |
| Mixed liquor | The mixture of waste water and recycled activated-sludge in the aeration tank of an activated-sludge plant. |
| Mogden formula | The formula for assessing the cost of conveyance and treatment of effluent and disposal of sludge. |
| Oxidation ditch | A cheaply constructed form of activated-sludge plant consisting of an elongated oval channel usually several metres wide and about 1·5 metres deep, provided with one or more electrically driven rotors which aerate and circulate the contents of the ditch and keep the activated-sludge in suspension. Settlement may be carried out in the ditch or in a separate tank. In the latter case activated-sludge is recycled as in a conventional activated-sludge plant. |
| Permanganate value (oxygen absorbed) | A measure of the oxygen absorbed by an effluent from N/80 acid permanganate in 4 hours at 27°C. It is an indication of the concentration of chemically oxidisable organic and inorganic matter present in sewage. It is less satisfactory for dairy effluent than for sewage since dairy effluents on fermentation produce organic acids which are resistant to oxidation by permanganate. |
| pH value | An indication of the acidity or alkalinity of an effluent on a logarithmic scale ranging from 0 (very strongly acid) to 7 (neutral) to 14 (very strongly alkaline). |
| 'Royal Commission' standard | The standard (suspended solids not to exceed 30 mg/l, BOD not to exceed 20 mg/l) to which the Royal Commission on Sewage Disposal considered that sewage effluents should be treated before discharge to a stream, assuming that the effluent would receive dilution with at least 8 volumes of clean river water (BOD less than 2 mg/l). |
| Screening | Removal of adventitious matter and coarse suspended solids from effluent by passage through a steel mesh or bar screen. |
| Settlement | The separation of suspended solid matter from waste waters as a sludge, by allowing it to settle under gravity during passage of waste waters through, or retention in, a tank. |
| Single filtration | Treatment of waste water by one passage though a biological filter. |

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| Sludge | Solids removed from waste waters by settlement. (Primary sludge is that sludge produced during the first stage of settlement, usually before biological treatment of a waste. Secondary sludge consists of humus and surplus activated-sludge solids produced during biological treatment and it is removed in the second stage of settlement.) |
| Suspended solids | Solid matter held in suspension in an effluent or waste water and capable of removal by filtration or by centriguation. |
| V-notch weir | A weir in which a V-shaped notch, usually with a 90° angle, is cut. From the level of the water surface above the base of the notch, the rate of flow of water can be calculated. |

# Appendix V

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